ENVIRONMENTAL STUDIES

HIGHER SECONDARY - FIRST YEAR

Vol — II

TAMILNADU TEXTBOOK SOCIETY

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Vol. II

HIGHER SECONDARY — FIRST YEAR

TAMILNADU TEXTBOOK SOCIETY
MADRAS

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8. Atmosphere — I

The blanket of air which surrounds the earth is known as the atmosphere. The earth is a unique planet in that it has an atmosphere surrounding it. The atmosphere makes life possible on the earth as it absorbs harmful ultra-violet radiation from the sun. The atmosphere acts like a blanket and this is responsible for the absence of extreme temperatures on the earth. The atmosphere is held by the gravitational force of the earth.

As the value of the gravitational force decreases with height, the density of the atmosphere is maximum on the earth's surface and decreases with height. It is estimated that about half of the total mass of the atmosphere lies within a height of about 5 km. Beyond this height the density of the atmosphere decreases more rapidly and about 99% of the mass of the atmosphere lies within a height of 29 km. The outer limit of the atmosphere cannot be fixed as it merges with outer space. It is estimated that atmosphere extends in a rarified form upto about 10,000 km. Most of the weather phenomena take place in the lower layers of the atmosphere.

Composition

Atmosphere comprises a mixture of gases, whose relative proportion remains nearly constant in the lower layers. This uniform composition is the result of intense mixing due to winds and currents. The relatively fixed components of the atmosphere are by volume Nitrogen (78.1%), Oxygen (20.9%), Argon (0.93%) and Carbon dioxide (0.033%). Variable constituents of the atmosphere are water vapour, dust particles, smoke, salt and pollen grains and micro-organisms.

The composition of the lower layers of the atmosphere is of great significance. All forms of life on the earth depend on the oxygen available in the atmosphere. Nitrogen from the

atmosphere is fixed by bacteria and made available for plants. Nitrogon from the atmosphere is used for the manufacture of fertilisers. Plants absorb carbon dioxide from the atmosphere during the process of photosynthesis. Water vapour in the atmosphere is responsible for rainfall, snow fall and other forms of precipitation. Minute particles of dust, smoke, salt and pollen grains provide nuclei for the condensation of water vapour.

The composition of the atmosphere is different above a height of 80 km. There are concentric layers of Nitrogen, Oxygen, Helium and Hydrogen one above the other, as they have progressively lower density. The boundary between these layers is transitional as one layer gradually gives place to another. The composition of these upper layers is no direct consequence to weather phenomena or life on the earth's surface.

Structure

We have already seen that the density of the atmosphere decreases with height. Temperature also varies with height in the atmosphere. These differences in the physical properties of the atmosphere form the basis for dividing the atmosphere into well defined layers concentric to one another.

The lowest layer is called the **Troposphere.** The density of the atmosphere is a maximum in this layer. Temperature of air decreases at an average rate of 1°C per 165 metres of height above sea level. The upper limit of the troposphere occurs at a height of 18 km. above the equator and 8 km. above the poles. The upper limit of the troposphere is known as the **Tropopause.** The height of the tropopause may vary according to seasons and such variations are related to changes in weather conditions. Most of the weather phenomena are limited to the troposphere.

Above the troposphere lies the **Stratosphere.** In this layer temperature increases with height, first slowly and then rapidly. Temperature increases with height because the ultra-violet rays from the sun are absorbed by ozone which is

concentrated between 15 and 35 km. of height. Stratosphere is free from clouds and associated weather phenomena and therefore provides ideal conditions for flying by jet aircraft. The upper limit of the stratosphere is known as the **Strato-pause** and lies at an altitude of about 50 km.

Height in km.	Name of Layer	Pressure in mb.	Temperature in °C
200	THERMOSPHERE	0.000001	+400°
100			
	IONOSPHERE		
90			
80	Mesopause	0.01	-60°
70		0.1	-50°
	MESOSPHERE		
60		0.3	-10°
50	Stratopause	1	+3°
40		3	-5°
30	STRATOSPHERE	12	-48°
20		56	-60°
	Tropopause		
10		264	-50°
0	TROPOSPHERE	1013	+15°

Fig. 8.1

Structure of the Atmosphere

[Note the varying thickness, pressures and temperatures of the different layers.]

Beyond the strastosphere lies a transtional layer called the **Mesosphere.** In this layer temperature decreases with height as in the troposphere. Mesosphere extends upto about 80 km. The atmosphere is rarified and the pressure is less than 0.1% of that at sea level. The upper limit of the Mesosphere is called the **Mesopause.**

The upper most layer of the atmosphere extends beyond the mesopause and is known as the **Thermosphere.** In this layer, temperature increases rapidly with height. At a height of 22 km., the temperature is estimated to be 400°C. The lower part of the thermosphere between 80 to 300 km. is known as the **Ionosphere.** In this layer ultra-violet radiation from the sun is absorbed by nitrogen and oxygen. These gases get electrically charged into ions. The formation of ionosphere is of great significance, as this layer reflects radio waves back to the earth and thus makes wireless communication possible.

Insolation

The word 'Insolation' is an abbreviation of the words 'incoming solar radiation'. The sun is the source of heat and energy for the earth. Large quantities of energy in the form of short waves is radiated by the sun in all directions. The earth owing to its small size and distance from the sun intercepts only 1 in 2,000,000,000 part of the total energy radiated by the sun.

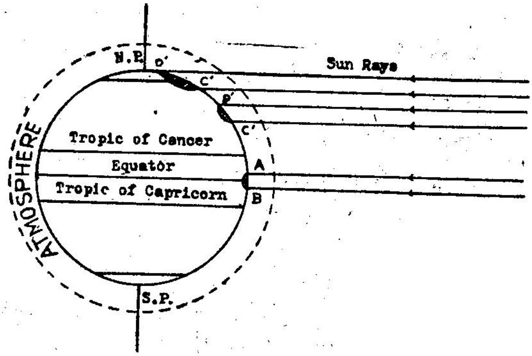

Fig. 8.2

Insolation

[Note that the angle of inclination of the sun's rays is vertical at the equator and horizontal at the poles.]

The average radiant energy reaching the outer limits of the earth's atmosphere on a surface perpendicular to the sun's rays is estimated to be 2 calories per sq. cm. per minute.

The insolation received shows variations from place to place on the earth and also with season even in the same place. These regional and seasonal changes in insolation are produced by the spherical shape of the earth and the revolution of the earth round the sun on an inclined axis. As the earth is spherical in shape, the sun's rays are vertical at only one point at a given time of the day. At other points, the angle of inclination of the sun's rays is less than 90°. For example, when the sun's rays are vertical over the equator, the angle of incidence is 0° at the poles. At intermediate latitudes, the angle of incidence is between 0° and 90°. At 60° latitude, the angle of sun's rays is only 30°.

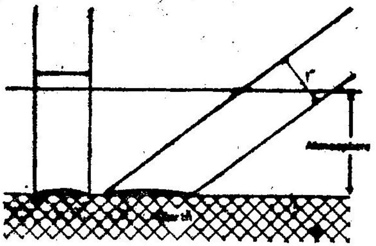

Fig. 8.3

Vertical and Slanting Rays

[Slanting rays diffuse the heat energy over larger area than the vertical rays.]

The energy derived from vertical rays is much greater than that derived from slanting rays. We experience this every day as mornings and evenings are cooler owing to slanting rays of the sun than midday when the rays are almost vertical. Vertical rays concentrate energy over a small area while slanting rays spread energy over a large area.

Seasonal Cycles

The axis of the earth is inclined at an angle of 23½° from the vertical. As the earth revolves around the sun with an inclined axis, the sun is not always overhead at the equator. There is an apparent movement of the sun north and south of the equator during the course of a year. This causes changes in the angle of inclination of the sun's rays and the duration of sunlight. (Table 8.)

ANGLE OF INCLINATION OF SUN'S RAYS AND DURATION OF DAY LIGHT

Latitude	23rd September and 21st March		21st June		22nd December	
	Duration of Day light	Angle of inclination	Duration of Day light	Angle of inclination	Duration of Day light	Angle of inclination
90° N	12 hours	0°	24 hours	23° 30′	0	0
66°30′N	12 ,,	23° 30′	24 ,,	47°	0	0
50°N	12 ,,	40°	16h 18m	66° 30′	7h 42m	16° 80′
23°30′N	12 ,,	66° 30′	13h 27m	90°	10h 33m	43°
0°	12 ,,	90°	12 hours	66° 30′	12 hours	66° 30′
23°30′S	12 ,,	66° 30′	10h 33m	43°	13h 27m	90°
50°S	12 ,,	40°	7h 42m	16° 30′	16h 18m	66° 30′
66°30′S	12 ,,	23° 30°	0	0	24 hours	47°
90°S	12 ,,	0°	0	0	24 hours	23° 30′

Table 8.1

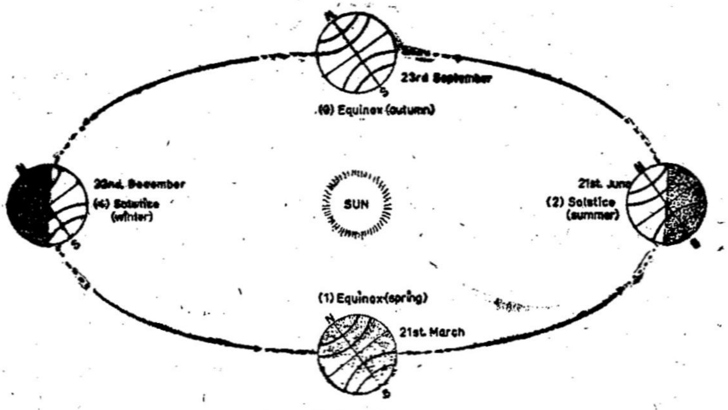

Fig. 8.4 **Seasons**
[Note the effect of the inclination of the earth's axis.]

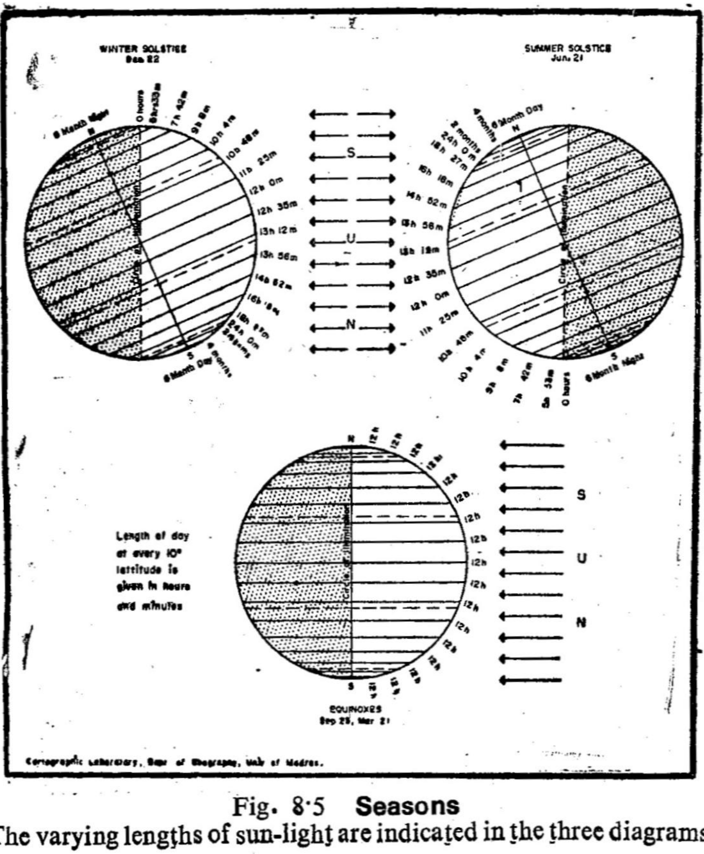

Fig. 8·5 **Seasons**
[The varying lengths of sun-light are indicated in the three diagrams]

On two days in the year—March 21st and September 23rd the sun's rays are overhead at the equator. The sun will be seen at the horizon at the poles. The angle of incidence decreases from the equator towards the poles. On these days every place on the equator has 12 hours of sunlight and 12 hours of darkness. Therefore, these two days are **equinoxes**.

From March 21st onwards there is an apparent movement of the sun northwards. The sun is overhead at points north of the equator progressively from March 21st. On June 21st, the sun's rays are overhead at the Tropic of Cancer (23½° North). The angle of inclination of sun's rays and the duration of sunlight are greater in the Northern hemisphere than in the Southern hemisphere. There is 24 hours of sunlight beyond the Arctic circle and there is 24 hours of darkness within the Antarctic circle. This position represents summer in the Northern hemisphere and winter in the Southern hemisphere. The sun appears to turn its path and move southwards after June 21st. This position is known as summer solstice for the Northern hemisphere.

During its apparent southward passage from the Tropic of Cancer the sun is overhead at the equator on September 23rd. Beyond this date the sun is overhead at places south of the equator. This apparent southward movement of the overhead sun continues upto December 22nd when the sun is overhead at the Tropic of Capricorn (23½° South). On this day, the angle of inclination of the sun's rays is greater in the southern hemisphere than the northern hemsiphere. The duration of sunlight is also greater in the southern hemisphere. This position marks summer season in the southern hemisphere and winter in the northern hemisphere. There is 24 hours of darkness within the Arctic circle and 24 hours of sunlight within the Antarctic circle. December 22nd is known as the winter solstice for the Northern hemisphere and from this date onwards the sun appears to move northwards till it is vertically overhead at the equator on March 21st. Thus it will be seen that the sun is overhead only between the **Tropic of Cancer and the Tropic of Capricorn.**

Temperature Zones

The following temperature zones are distinguished on the basis of the distribution of insolation on the surface of the earth. The region between the Tropic of Cancer and the Tropic of Capricorn is known as the **Torrid Zone.** In this zone the angle of inclination of sun's rays is between 66½° and 90° during the year. Therefore this region receives large quantities of insolation throughout the year.

The regions between the Tropic of Cancer and the Arctic circle in the Northern hemisphere and that between the Tropic of Capricorn and the Antarctic circle in the southern hemisphere are known as the **Temperate Zones.** These zones

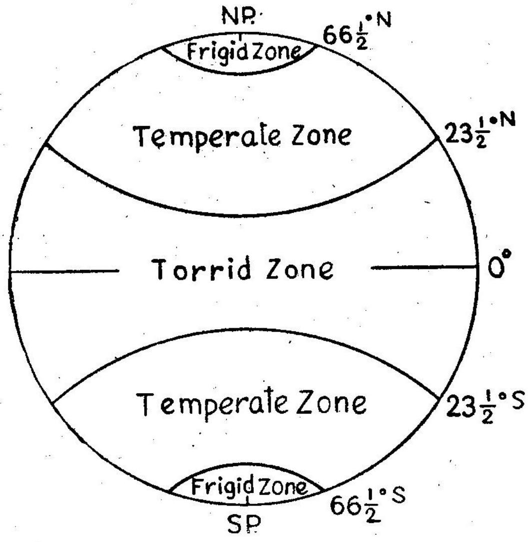

Fig. 8.6

Temperature Zones

do not experience extreme heat of the Torrid zone or extreme cold of the Polar regions. The angle of incidence of the sun varies between 66½° and 23½° during the year. There is

strong contrast between summer and winter in the angle of inclination of sun's rays and the duration of sunlight. The sun's rays are never overhead in this zone.

Beyond the Arctic circle in the northern hemisphere and beyond the Antarctic circle in the southern hemisphere are two zones of extreme cold called the **Frigid Zones.** In this zone, there is 24 hours of darkness during winter and 24 hours of sunlight during summer. But as the angle of incidence in summer is not exceeding 47°, the amount of insolation received is only moderate. In the frigid zones there is strong contrast between summer and winter.

Processes of Heating of the Atmosphere

The differences noticed in the distribution of insolation according to latitude and seasons is not felt to the same extent in the temperature of the atmosphere. This is because the atmosphere does not get heated directly by the incoming rays of the sun. The atmosphere is transparent to the insolation, as only 14% of it is absorbed by the atmosphere. About 35% of the insolation is reflected by clouds and the surface of the earth and is returned to space. Rest of the insolation, namely 51 units out of 100, is absorbed by the earth's surface. This heats the surface of the earth and the heated surface in turn radiates heat back to space. The heat radiated by the earth is known as Terrestrial radiation. The terrestrial radiation is in the form of long waves in contrast to the insolation which is in short waves. Out of 51 units of heat radiated back by the earth's surface, 34 units, i.e., 66%, is directly absorbed by the atmosphere. The remaining 17 units are directly radiated back to space. It will be seen from the above description that the atmosphere allows insolation to pass through without getting heated during its passage, and gets heated primarily from below by the terrestrial radiation from the earth's surface.

Heat Balance

The earth and the atmosphere surrounding it are in a state of heat balance if we consider the system as a whole. Neither the earth nor the atmosphere gets progressively heated or

cooled and the heat energy absorbed by them is radiated back to space. If we assume that 100 units of heat energy are received from the sun, the amount radiated back is also 100 units. This comprises 35 unit of insolation directly reflected by the earth and the atmosphere, 17 units radiated directly by the earth and 48 units radiated by the atmosphere.

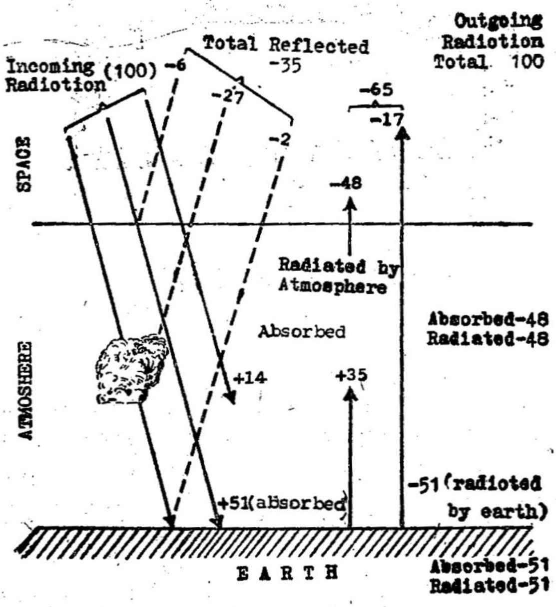

Fig. 8.7

Heat Balance

[Note the processes involved and the balance between incoming and outgoing radiation.]

The atmosphere absorbs 14 units from insolation and 34 units from terrestrial radiation, making a total of 48 units. The atmosphere also radiates 48 units back to space and thus a balance is maintained between the amount absorbed and that radiated. The earth's surface absorbs 51 units of energy from insolation and radiates back 51 units as terrestrial radiation. Thus a balance is maintained.

Though heat balance is maintained if we consider the earth and the atmosphere as a whole, there are differences between heat energy received and that radiated if we take different latitudes. In the low latitudes, the amount of insolation received is much more than that received in middle and

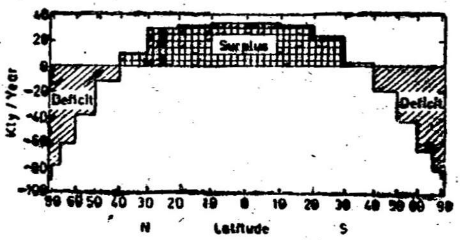

Fig. 8.8

Latitudinal Heat Balance

[Note the surplus in low latitudes and deficit in high latitudes.]

high latitudes. In the region between 37° North and 37° South latitudes, the amount of heat energy received is much more than the amount of energy radiated outwards. Thus there is a surplus of energy in this region. In the latitudes beyond 37° North and South, the amount of energy radiated outwards is much more than the energy received from insolation. This would be possible only if there is some way by which the surplus heat from the low latitudes is transferred to the middle and high latitudes. This transfer of heat is taking place through circulation in the atmosphere and oceans. It is seen from the above that the differential heating of the atmosphere is primarily responsible for the setting up of circulation in the atmosphere and the oceans.

Factors Controlling Temperature

The temperature of the atmosphere shows variations between day and night and also between seasons. It also shows variations from one place to another at the same time. If we consider the daily cycle of temperature, it is a minimum just before sun-rise and starts rising till about 2 P.M. and reaches a maximum. The temperature of the atmosphere rises upto

about 2 P.M. because the amount of heat energy received is in excess of that lost by radiation. After 2 P.M., the slanting rays of the sun are less effective in heating the atmosphere and the loss of heat by radiation is taking place even during the night. Therefore temperature decreases and reaches a minimum just before sun-rise.

Besides this daily cycle of temperature, there is a seasonal cycle also. If the temperature changes during the course of a year are examined, it is seen that there is a maximum during summer and a minimum during winter. This is caused by the greater angle of inclination of the sun and the longer duration of sunlight during summer than during winter. Besides these daily and seasonal changes, other factors also influence the temperature of a place.

Latitude of a place is an important factor which controls the temperature of a place. We have already examined the distribution of temperature zones on the basis of latitude. It is seen that as we move away from the equator, there is a general tendency for the temperature to decrease. This happens because, the angle of inclination of the sun's rays and the duration of sunlight vary according to latitude. Generally, the longer duration of sunlight in the higher latitudes does not compensate for the low angle of inclination of the sun. If latitude were the only factor, the highest temperature would be found in the equatorial region and the lowest temperature would be found in the polar region. But this is not actually found as other factors also influence the temperature.

Land and Sea Contrasts

We know that the atmosphere gets heated primarily by the radiation from the earth's surface. The major contrasts on the earth's surface are between land and sea. As the physical properties of land and sea are different, they do not get heated by insolation in the same manner. Land gets heated by conduction and as rocks and soils are bad conductors of heat, only a thin surface layer gets heated. Therefore temperature rises rapidly during the day time and in the night

temperature falls equally rapidly by radiation. The sea surface reflects a part of the insolation and the remaining part heats the sea surface. Heat is distributed into the lower layers by the process of convection. Water has higher specific heat than land. This means more heat energy is needed to heat one gram of water than one gram of land. Therefore, water gets heated more slowly and to a lesser extent than the land and gets cooled also more slowly. Therefore, contrasts in temperature between day and night as also between summer and winter are greater on land than on the sea. This explains the strong contrasts in temperature between coastal and interior regions.

Ocean Currents, Prevailing Winds and Other Factors

The effect of ocean currents on the temperature of adjoining land masses has been described in great detail in the chapter on the Hydrosphere. Prevailing winds modify the temperature of the areas over which they blow. For example, winds from cold land areas reduce the temperature; winds from warm oceans increase the temperature. Cloudiness is another factor affecting the temperature. Cloud-cover in the sky reduces the temperature, while clear skies lead to higher temperature.

Altitude

The elevation above sea level is one of the factors affecting temperature. We know that mountain ranges are cooler than the plains. Temperature decreases with height at an average rate of 1°C per 165 metres of ascent. Temperature decreases with height because the atmosphere gets heated primarily from below by the radiation of heat from the earth's surface. Secondly, the ability to absorb the terrestrial radiation and get heated is less in the upper layers owing to the lower quantity of water vapour, carbon dioxide and dust particles present at these levels than at the lower levels. The reduction of temperature with height explains the lower temperatures of Bangalore compared to Madras.

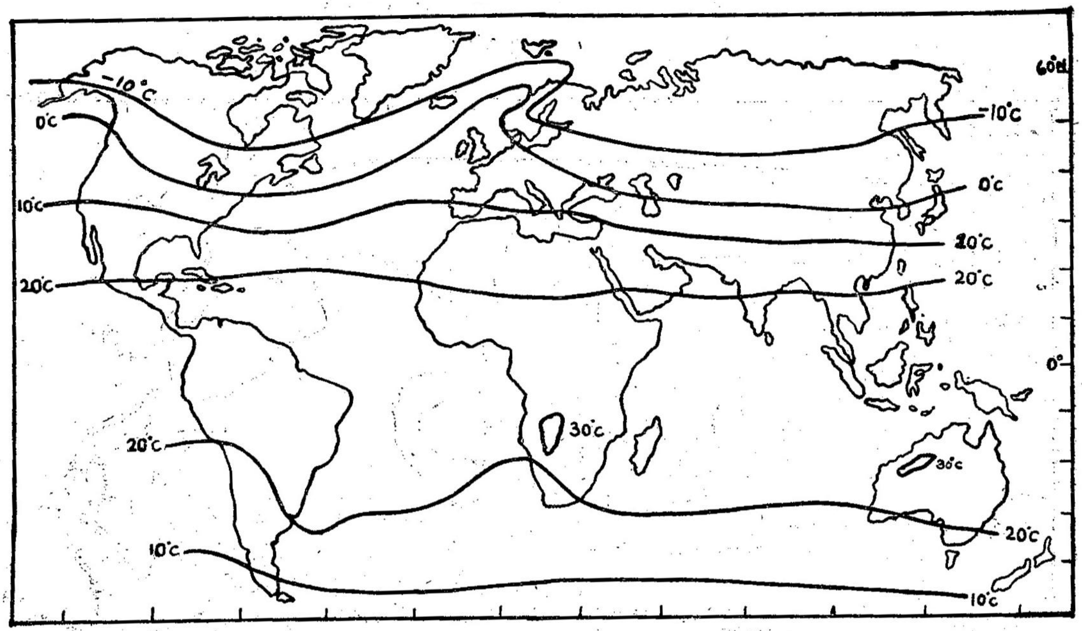

Fig. 8.9

Distribution of Temperature — **January**

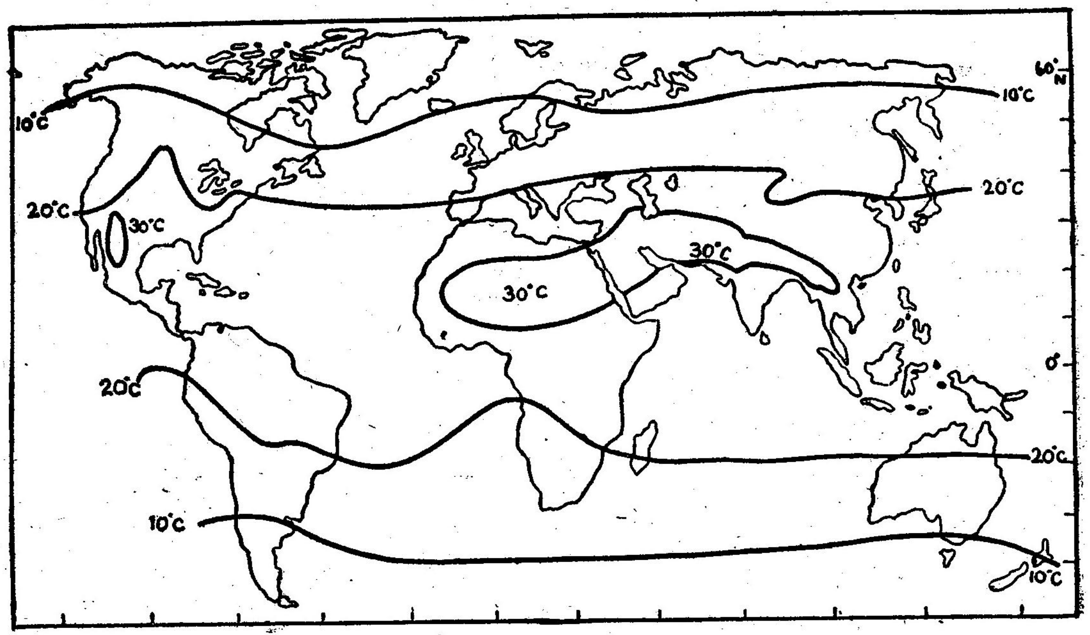

Fig. 8.10

Distribution of Temperature — July

Global Patterns of Temperature

Study the world maps showing temperature conditions in January and July. The distribution of temperature is shown on these maps by lines called **isotherms**. These are lines joining places having the same temperature. The temperature values of stations are reduced to sea level in order to eliminate the effect of altitude. It will be seen from these maps that the isotherms are not straight lines parallel to lines of latitude. The pattern of land and sea distribution affects the trend of the isotherms. Examine the contrast between land and sea on each map and also the contrast between the northern and southern hemispheres. Why is it that contrasts between land and sea are greater in the northern hemisphere than in the southern hemisphere?

Atmospheric Circulation

We have known that the atmosphere is restless except for very short periods of time. The restlessness of the atmosphere reaches maximum intensity during cyclones when winds blow with velocity exceeding 100 km. per hour. We have seen earlier that differential heating of the atmosphere is one of the causes which bring about movement in the atmosphere. Another factor which brings about restlessness in the atmosphere is the rotation of earth. Atmospheric circulation plays an important role in the transfer of heat energy and also water vapour.

The layer of atmosphere surrounding the earth exerts weight or pressure at an average rate of 1 kg. per sq. cm. at sea level. The pressure of the atmosphere decreases with height. Pressure of the atmosphere also changes temperature. When temperature increases, air expands and rises and laterally spreads at higher levels. This causes decrease of pressure. Decrease of temperature causes cooling and contraction of air leading to an increase of pressure. Similarly, ascending currents of air lead to a decrease in pressure, while descending currents cause an increase in pressure.

Major Pressure Belts

The following major pressure belts are distinguished on the basis of pressure differences observed at sea level on the surface of the earth.

The Equatorial Low Pressure Belt lies on both sides of the equator extending to about 10 degrees north and south. This is a region of uniformly high temperature throughout the year. Air gets heated and rises upwards by convection. Ascending air spreads laterally at high levels leading to a decrease of pressure at the surface. Thus the Equatorial low pressure belt is produced

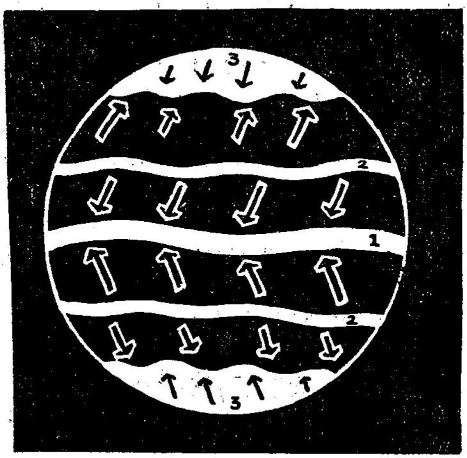

Fig. 8.11

Major Pressure and Wind Belts

1. Equatorial low pressure 2. Sub-tropical high pressure 3. Polar high pressure

by extreme heating of the atmosphere. **The Polar High** Pressure Belt occurs over the polar regions around the north and south poles. This is a region of low temperature and cooling of the atmosphere leads to contraction and increase of pressure.

While the Equatorial Low pressure belt and the Polar High pressure belts are caused by the differential heating of the atmosphere, the effect of rotation of the earth causes two other pressure belts between the equator and the poles. These pressure belts are called the **Sub-tropical High** Pressure and the **Sub - Polar Low** Pressure Belts.

Sub-tropical High pressure belts are formed at latitudes of about 30 to 35 degrees north and south. This high pressure is produced by descent of air from higher levels. Air which ascends at the Equatorial region spreads laterally at high levels and flows towards the poles. The rotation of the earth causes this air to descend downwards at these latitudes and thus leads to high pressure.

Sub-Polar Low Pressure Belts lies at the latitude of about 60° north and south between the Sub-Tropical High pressure belt and the Polar High pressure belt. This region is not a belt of permanent or intense low pressure like the equatorial region. This is a zone of variable low pressure, caused by the ascent of warm sub-tropical air over the cold polar air.

Major Wind Belts

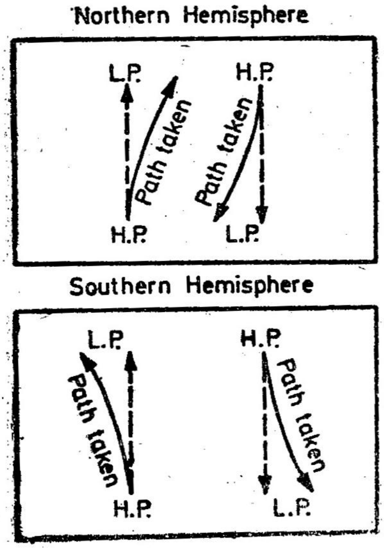

Fig. 8.12

Ferrel's Law

[Note the deflection caused by rotation of the earth.]

The movement of air from high pressure to low pressure causes winds. The rotation of the earth causes deflection of the path of the winds. This is stated by **Ferrel's law.** According to this law, all moving bodies are deflected to the right in the northern hemisphere and to the left in the southern hemisphere.

For example, in the northern hemisphere, wind blowing from the sub-tropical high pressure belt to the equatorial low pressure belt must blow from the north towards the south. This gets deflected and blows as a north-easterly wind.

Trade Winds

Winds which blow from the Sub-tropical high pressure belts towards the Equatorial low pressure belts are called Trade Winds. These winds are strong and steady in direction. They are north-easterly winds in the northern hemisphere and south-easterly in the southern hemisphere.

Westerlies

Westerlies are winds which blow from the Sub-tropical high pressure belts towards the Sub-polar low pressure belts. These blow from the south-west in the northern hemisphere and from the north-west in the southern hemisphere. These winds transport the warm sub-tropical air to higher latitudes.

Polar Easterlies

Winds blowing from the Polar high pressure to the sub-polar low pressure belts are generally weak and variable winds. They are called Easterlies as they blow from a general easterly direction. The general direction of these winds is north-east in the northern hemisphere and south-east in the southern hemisphere.

Seasonal Migration of Pressure and Wind Belts

The generalised pattern of major pressure and wind belts shows seasonal variations caused by the apparent migration of the sun. During the equinoxes, that is March and September, the pressure wind belts are located in their average positions. During the summer season in the northern hemisphere, the pressure and wind belts move northwards, as the sun apparently migrates from the equator towards the Tropic of Cancer. During the summer season in the southern hemisphere, the pressure and wind belts move southwards in response to the apparent movement of the sun from the equator to the Tropic of Capricorn. In each hemisphere, the pressure and wind belts migrate polewards during the summer season and equatorwards during the winter season. This migration leads to seasonal variations in the pressure conditions and the resultant winds.

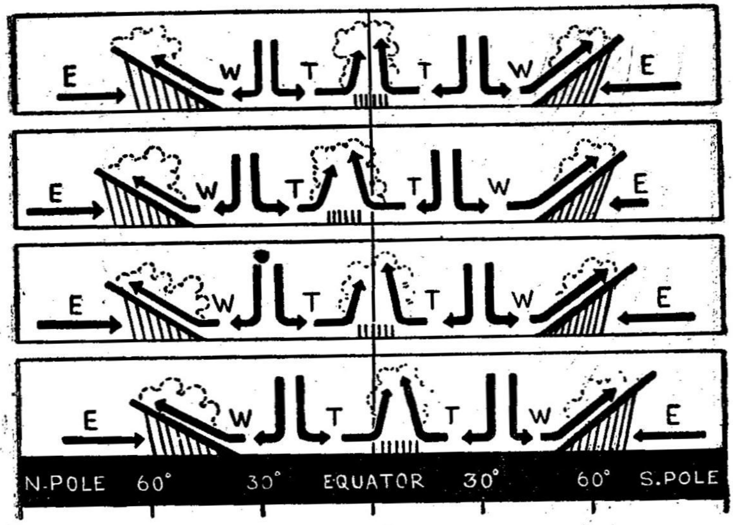

Fig. 8.13

Seasonal Migration of Pressure and Wind Belts

[Note the Zones of ascending and descending currents. Ascending currents are found associated with the equatorial low and sub-polar low pressure belts. Descending currents occur in the sub-tropical high pressure be'ts.]

T-Trade Winds, W-Westerlies, E-Easterlies.

1. March 21st 2. June 21st 3. Sept. 22nd 4. Dec. 23rd

Global Patterns of Pressure and Winds

The pattern of pressure and winds during the months of January and July are represented on the maps of the world. These maps indicate that the actual conditions are different from the pattern of major pressure and wind belts described earlier. This is brought about by the marked differences between land and sea. As land and sea contrasts are more striking, belts of pressure get modified into cells of high and low pressure. Land masses are occupied by cells of high pressure during winter and low pressure during summer. The oceans

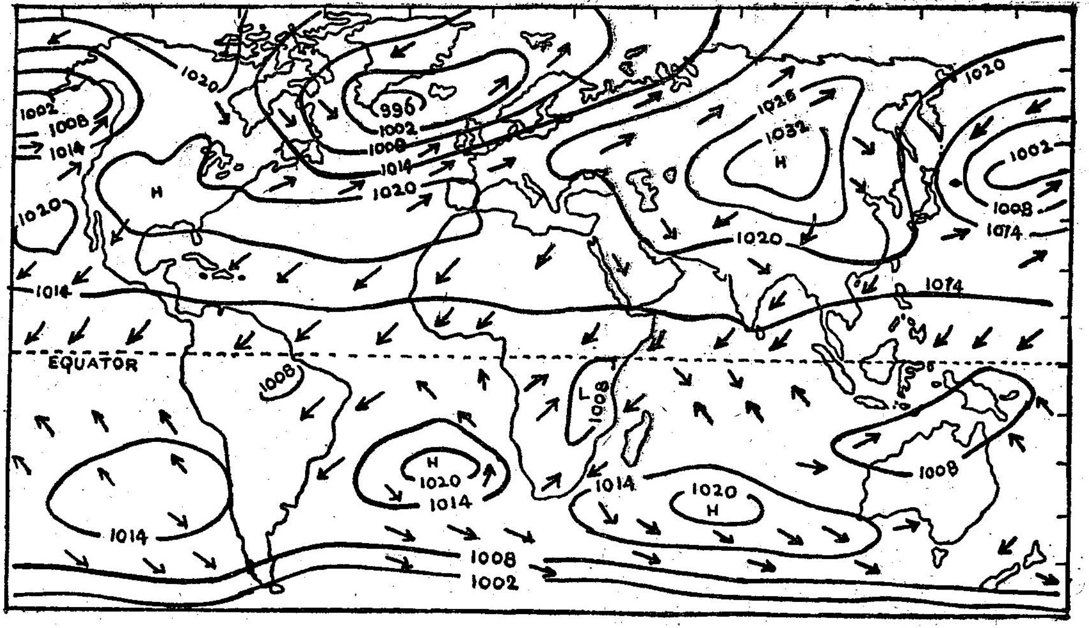

Fig. 8.14

Pressure and Wind Conditions — January

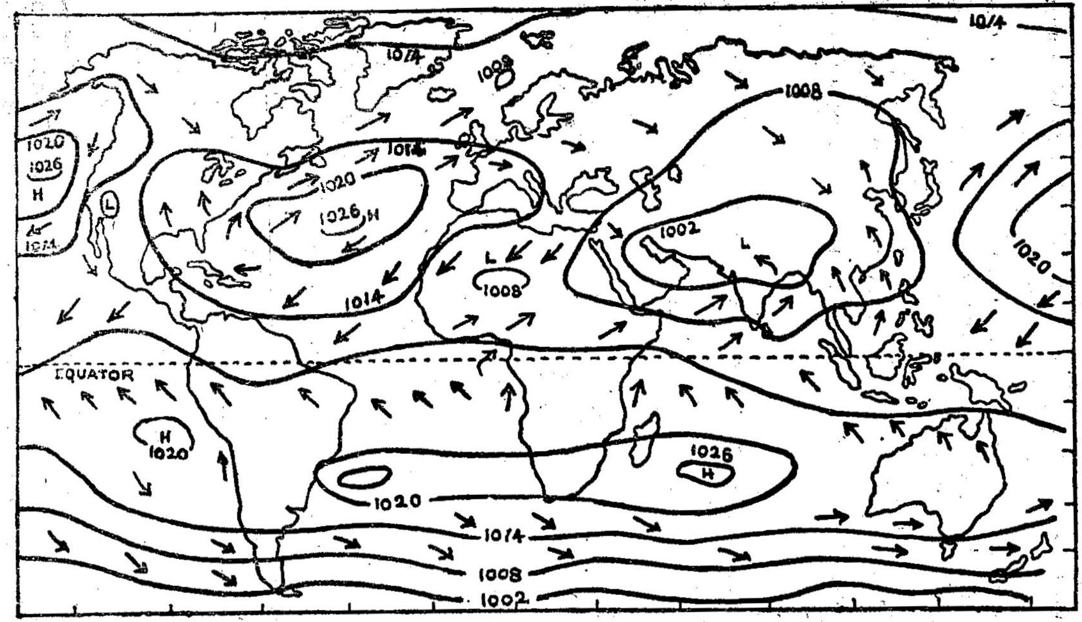

Fig. 8.15

Pressure Wind Conditions — July

on the other hand are covered by cells of relatively high pressure during summer and low pressure during winter. Circulation of winds is oriented to the distribution of cells of low and high pressures. In the northern hemisphere, there is a counter-clockwise circulation of winds around a low pressure and clock-wise circulation around a high pressure. In the southern hemisphere, the circulation is clockwise around a low pressure and counter-clockwise around a high pressure. An examination of the two maps will also bring out the seasonal migration of the cells of high and low pressure.

Monsoons

Monsoons are seasonal winds which experience reversal in their direction between one season and another. Monsoon winds are produced by the marked contrast between large landmasses and adjoining oceans. Monsoon winds are well

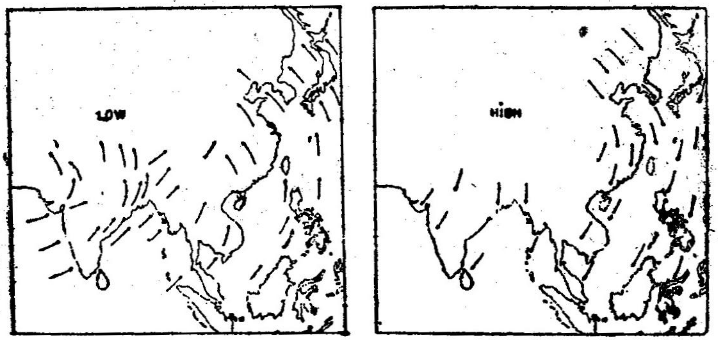

Fig. 8.16

Monsoons (after OW Freeman and HF. Raup)

[Note the contrast between low pressure in summer and high pressure in winter and associated wind systems.]

developed over southern and eastern parts of Asia. During summer there is an intense low pressure over the continent with the lowest pressure in the lower Indus Valley. Higher pressure prevails over the Indian ocean towards the south and the Pacific ocean towards the east. Therefore winds blow from the surrounding oceans towards the coastal regions of

southern and eastern Asia. Thus during the summer season, south-westerly winds blow overs outhern Asia, while south-easterly winds blow over eastern Asia such as China and Japan. As these winds blow from sea to land, they give rainfall to most parts of Asia. The amount of rainfall varies depending on the distance from the coast and the relief of the land.

During winter season, the land masses cool rapidly and a high pressure develops in the centre of the continent of Asia. Winds blow outwards from the high pressure cell towards the surrounding oceans. These winds are north-easterly over southern Asia and north-westerly over eastern Asia. It will be seen that the direction of winds is the opposite of that during the summer season. These land winds do not give much rainfall except when they pass through parts of oceans along their path.

Other Pressure and Wind Systems

Apart from the major pressure and wind belts and the monsoons there are other pressure and wind systems of local importance. These include, cyclones, anti-cyclones, and local

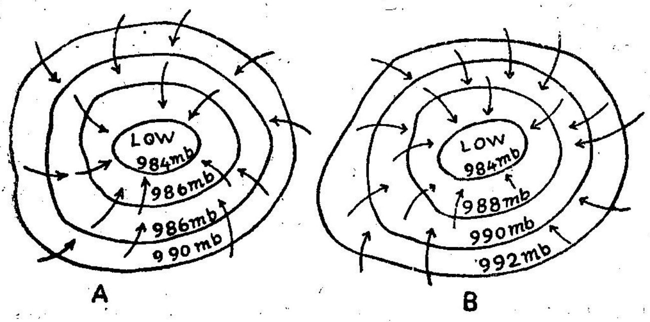

Fig. 8. 17 **Cyclone**

[A. Northern hemisphere B. Southern hemisphere]

winds. A cyclone is a centre of low pressure which moves along a general path and lasts a few days. As air from the surrounding regions rushes in towards the low pressure, cyclones are associated with strong winds. Winds blowing towards the centre of the cyclone ascend up and this

causes rainfall along the path of the cyclone. Winds blow around a cyclone in an anti-clockwise direction in the northern hemisphere and clock-wise direction in the southern hemisphere. Cyclones are more numerous in the belt of the westerlies than in the tropical regions. Tropical cyclones originating in the Bay of Bengal affect the coastal tracts of Tamilnadu, Andhra Pradesh, Orissa and West Bengal.

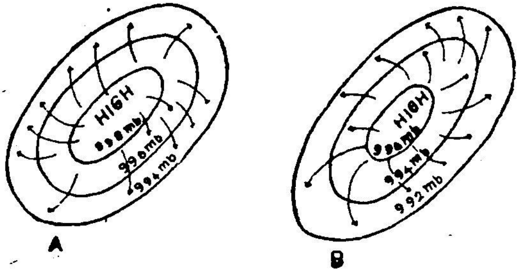

Fig. 8.18 **Anti-cyclones**

[A. Northern hemisphere B. Southern hemisphere]

Anti-cyclones are centres of high pressure from which winds blow out in all directions. They are associated with descending air currents. They give rise to clear skies and fair weather conditions.

Local winds affect only limited tracts and they may last a few hours or days depending on local factors. Land and sea breezes are typical examples of such winds. In the coastal region sea breeze is commonly experienced in the afternoon and evening. This is because low pressure is developed over the land owing to higher temperature than on the adjoining sea. During the night the land cools more rapidly and a high pressure is formed. Hence, land breeze blows from land to sea during the night.

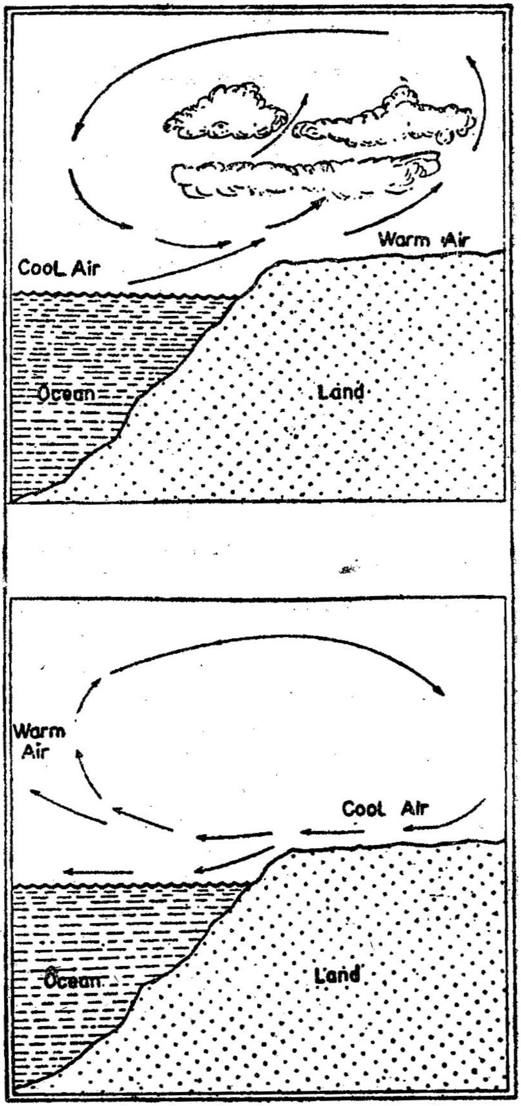

Fig 8.19

Land and Sea Breezes

[The top figure shows sea breeze and the bottom figure shows land breeze]

EXERCISE — 8

Short Answer Questions:

1. Describe the composition of lower layers of the atmosphere.
2. Distinguish between troposphere and stratosphere.
3. Why does insolation vary from place to place at a given time?
4. Why is it that the insolation received at a place is not the same throughout the year?
5. In what region of the earth is the sun overhead at least once during the year?
6. Indicate the limits of the North Temperate and South Temperate zones.
7. How do you conclude that there is a heat balance on the earth and the atmosphere surrounding it?
8. What causes circulation in the atmosphere and the oceans?
9. Study the world map showing temperature conditions in January and describe the distribution of temperature. Bring out the contrast between the Northern and Southern hemispheres.
10. Name the major pressure belts and indicate their approximate location in terms of latitudes.
11. State Ferrel's law.
12. Why is there a seasonal migration of pressure and wind belts?
13. Study the world map showing pressure and wind conditions in January and describe the conditions. Bring out the contrast between land and sea.
14. Distinguish between cyclones and anti-cyclones.
15. What are local winds? Give an example.

Essay Questions:

1. Give an account of the structure of the atmosphere.
2. How are seasons caused? Describe briefly the seasonal cycles.
3. Describe the processes of heating of the atmosphere.
4. Give a clear account of the major pressure and wind belts of the world.
5. Give a brief account of the Asiatic monsoon.

9. Atmosphere — II

Moisture in the atmosphere

We have seen in the last chapter that water vapour is one of the variable constituents of the atmosphere. The quantity of water vapour present varies from place to place and also with time at the same place. The average content of water vapour in the atmosphere is equivalent to 2.5 c.m. of rainfall. This means if all the water vapour present in the atmosphere at a time were to be precipitated on the earth, it will give a rainfall of 2.5 cm. Though the quantity of water vapour present at any one time in the atmosphere is very small, it plays an important part. Water vapour accounts for the formation of clouds and precipitation. When water vapour condenses, it releases latent heat and this is a source of energy for the atmospheric processes.

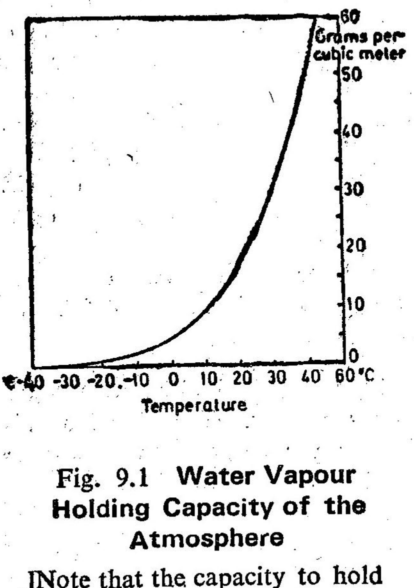

Fig. 9.1 **Water Vapour Holding Capacity of the Atmosphere**

[Note that the capacity to hold water vapour increases steeply beyond 20°C.]

Relative Humidity

Humidity is a measure of the water vapour content of the atmosphere. **Absolute humidity** expresses the quantity of water vapour in terms of grams of water vapour per cubic metre of air. This measure of humidity is of less significance compared to the **Relative Humidity.** The quantity of water vapour which the atmosphere can hold as vapour at a given temper-

ature is limited. The capacity to hold water vapour increases with temperature. Relative humidity is a ratio between the actual quantity of water vapour present in the air and the maximum quantity that the atmosphere can hold at that temperature. Relative humidity is expressed as a percentage.

A sample of air at a temperature of 30°C has 10 gms. of water vapour per cu. metre. The maximum quantity of water vapour that can be held by the atmosphere at 30°C is 30 gms. Therefore, relative humidity of the sample of air is equal to 10/30 x 100, i.e., 33.3 %. When the relative humidity is 100 % the atmosphere is said to be saturated.

Relative humidity of the atmosphere depends as much on the water vapour content of the atmosphere as on the temperature. Relative humidity increases by decrease of temperature or addition of water vapour. Relative humidity of the sample of air having 10 gms. of water vapour per cubic metre at 30°C increases to 58.4°C if the temperature is reduced to 20°C. Again, if temperature remains the same, viz., 30°C, relative humidity will increase to 50% if 5 more gms. of water vapour are added per cu. metre of air. Relative humidity decreases if temperature increases or if water vapour content decreases. For example if the sample of air having 10 gms of water vapour per cu. metre of air at 30°C gets heated and its temperature rises to 40°C. its relative humidity will be reduced to 20%.

Thus unsaturated air will get saturated either as a result of cooling or addition of water vapour. The parcel of air having 10 gms. of water vapour per cubic metre of air at 30°C will get saturated when its temperature is reduced to 10°C. owing to cooling. If temperature remains at 30°C, saturation will take place when 20 more gms of water vapour cupermetre are added to the sample of air. Cooling of air is the more common process by which, air gets saturated.

Evaporation

The process of evaporation and the factors controlling it have been examined in the chapter on the Hydrosphere. Evaporation is a maximum in sub-tropical regions owing to

high temperature, clear skies and strong trade winds. Evaporation is a minimum in the polar regions. Relative humidity of the atmosphere is also a factor controlling evaporation. If air is already saturated, that is having a relative humidity of 100%, no further addition of water vapour is possible to the atmosphere. Unsaturated air can absorb more water vapour owing to evaporation.

Transpiration of water vapour by plants also adds water vapour to the atmosphere. This depends on the type of vegetation and its density. The combined effect of evaporation and transpiration is known as evapo-transpiration. This gives a measure of the total quantity of water vapour added to the atmosphere.

Condensation

Condensation is the process by which water vapour in the air gets converted into minute droplets of water or into ice. Condensation takes place only in saturated air. When saturated air is cooled, its capacity to hold water gets reduced and the excess of water vapour gets condensed. For example, saturated air at 30°C contains 30 gms, of water vapour per cu. metre of air. If it is cooled to 20°C it can hold only 17 gms. of water vapour per cu. metre and therefore. 13 gms. of water vapour per cu. metre gets condensed. Cooling of warm air leads to greater amount of condensation than the cooling of cold air. For example, if saturated air at 10°C is cooled to 0°C, the resulting condensation is only 4.6 gms. of water vapour per cu. metre.

Cooling of air leading to condensation may take place when air moves from warm sea to cold land or from warm land to cold sea, or when warm air mixes with cold air. More commonly, cooling of air takes place owing to ascent of air.

Condensation may take place without any cooling of air. This happens when more moisture is added to saturated air. When saturated air moves over ocean surface or other large water bodies, condensation results.

Condensation takes place only when minute solid particles such as dust, smoke, salt and pollen grains are present in the air. Water condenses around these particles as minute droplets. These particles are called hygroscopic nucleii or condenstion nucleii. Millions of such particles are present in each litre of air in the lower layers of the atmosphere.

Clouds

Clouds contain minute droplets of water or crystals of ice produced by condensation of water vapour. These particles are so small that they remain suspended in the air and do not fall down. Clouds are classified according to shape into three main groups. Cumulus clouds are cauliflower shaped clouds with vertical development. Stratus clouds appear as thin sheets or layers. Cirrus clouds appear like thin feathers or streaks. There are several combinations of shapes. Clouds may also be classified into high, medium and low clouds according to their height.

When condensation takes place near the ground, it is known as **fog**. Tiny droplets of water formed by condensation reduce visibility. Fogs are more common in winter. Less intense fog is known as **mist**. Fog occurs commonly over industrial regions, as condensation takes place around tiny particles of smoke.

Precipitation

Precipitation is the process by which the condensed water falls to the earth's surface in various forms. The tiny droplets of water and ice in the cloud do not fall to the ground unless they grow in size to enable them to fall by their own weight. An average rain drop has a size about a million times that of a cloud droplet. Aggregation of cloud droplets into rain drops may take place either by the growth of ice crystals in the cloud or as a result of collisions between them. The physical processes involved in precipitation are more complex than those of condensation. The precipitation processes result in aggregating millions of cloud droplets into smaller number of large rain drops.

Forms of Precipitation

The most common form of precipitation is rainfall. This occurs as drops of water varying in size from 1 mm. to 6 mm. in diameter. Drizzle consists of smaller particles which fall slowly. When rain falls through a cold layer of air near the earth's surface, the rain drops get frozen and this type of precipitation is called **sleet.** Sleet may also include a mixture of rain and snow. When condensation takes place below freezing point, ice crystals get formed in the cloud and these may fall through the atmosphere as powdery masses of snow or crytals of ice. This type of precipitation is called **snowfall. Hail** consists of crystals of ice, a few centimetres in diameter. Such hail stones may cause damage to crops and buildings.

Types of Rainfall

We have seen in the earlier paragraphs that condensation takes place only when air is cooled leading to its saturation. Cooling may take place when air ascends in one of three ways. The most common cause for ascent of air is the process of

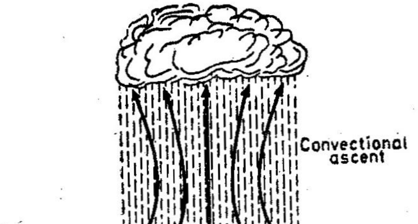

Fig. 9.2

Convectional Rainfall

convection. In the equatorial regions, the earth's surface gets heated and the air above it also gets heated. Heated air expands and becomes less dense than the surrounding air. This leads to ascent of air. Such ascent is especially significant in the afternoons and this gives rise to clouds of great vertical development. Such convectional ascent gives rise to sudden downpour of

rainfall accompanied by thunder and lightning. This type of rainfall is known as **convectional rainfall.** Convectional rainfall may also occur in regions away from the equator if conditions favour vertical ascent of air. Such conditions occur during summer in the interiors of continents.

Sometimes air is forced to ascend up the steep slopes of a mountain range or edge of a plateau. Such ascent may lead to cooling and condensation. Further ascent leads to rainfall. This type of rainfall is called the **orographic rainfall.** This type of

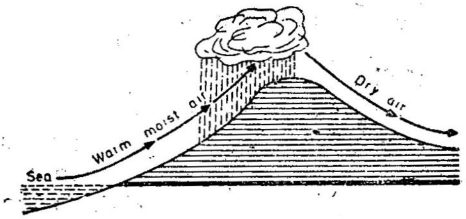

Fig. 9.3

Orographic Rainfall

rainfall is specially heavy when the relief barriers are at right angles to the direction of winds and are located near the coast. The best example is the heavy rainfall on the western slopes of the Western Ghats produced by the ascent of monsoon air. A feature of orographic rainfall is the strong contrast between the windward and leeward slopes. While the windward slopes get heavy rainfall, the leeward slopes are dry as they are in the rain shadow zone. The eastern slopes of the Western Ghats are in the rain shadow zone. This explains the strong contrast in rainfall between Bombay and Poona.

Cyclonic Rainfall is associated with the circulation of winds around a low pressure. In the sub-polar low pressure belt warm westerlies ascend gradually above cold and dense polar air. This causes rainfall along the zone of ascent of warm air. In

the tropical regions, cyclones give heavy rainfall due to ascent of air around the low pressure centre. The path taken by the cyclone is marked by a belt of heavy rainfall.

Fig. 9.4

Cyclonic Rainfall

Distribution of Rainfall

The pattern of distribution of rainfall may be examined with reference to the major pressure and wind belts and the location of continents and oceans. There are two zones of heavy rainfall associated with the equatorial and sub-polar low pressure belts. These are zones of ascending air and therefore rain is more prevelent in these zones. The sub-tropical high pressure belts and the polar high pressure belts are zones of descending air and therefore these zones are relatively dry.

This general latitudinal pattern is modified by the uneven distribution of continents and oceans. Winds which blow from ocean to land are moisture laden and give heavy rainfall along the coast. Winds which blow from land to oceans are relatively dry and do not give much rainfall. The direction of prevailing winds is therefore an important factor.

In the belt of the trade winds, there is strong contrast in rainfall between the eastern and western margins of continents. On the eastern margins, winds blow from ocean to land and therefore they give heavy rainfall. Rainfall decreases towards the west and the western margins are deserts. In this region winds blow from land to sea and they are dry winds.

In the westerly wind belt in the middle latitudes, maximum rainfall is received on the western margins of continents and

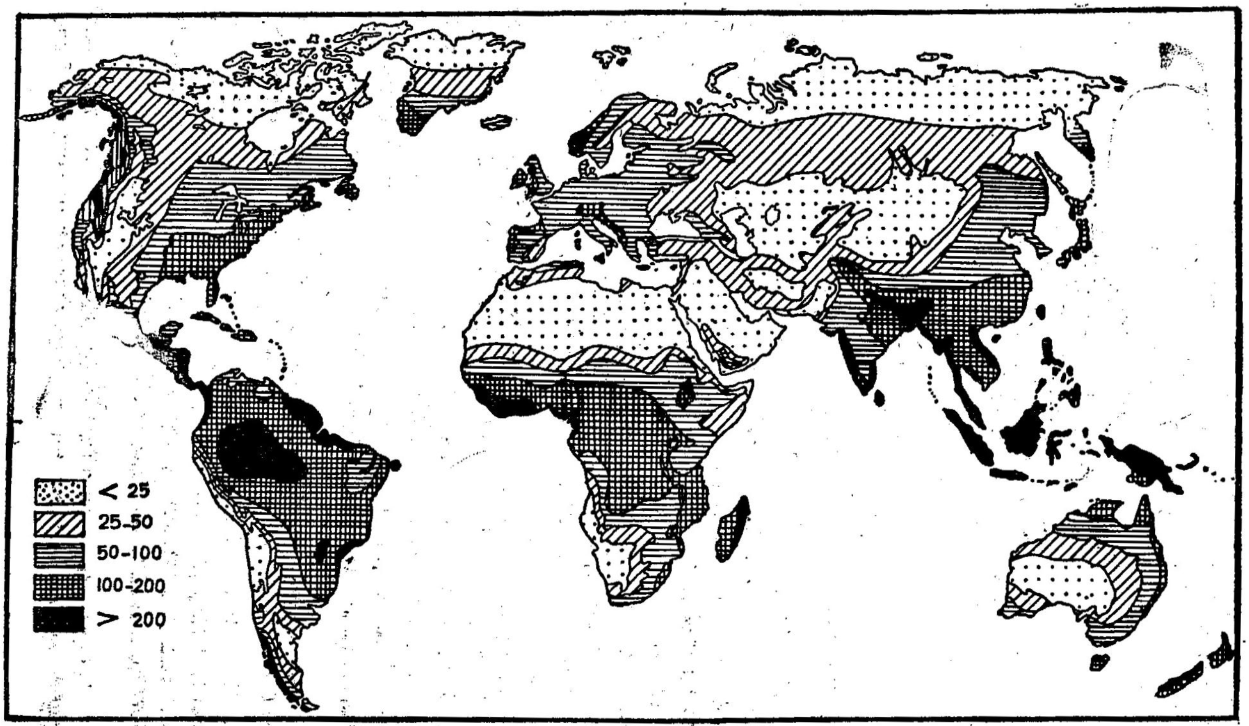

Fig. 9.5 **World Distribution of Annual Rainfall**

rainfall decreases towards the interior. These interior regions of large continents form mid-latitude deserts.

The distribution of precipitation in the world shown on the map brings out clearly the combined influence of all these factors. Regions having more than 150 cm. of precipitation during the year are the equatorial region, tropical monsoon region and mid-latitude west margin region. The equatorial region includes the Amazon and Congo basins and the islands of Indonesia. The tropical monsoon region comprises parts of India, South-east Asia and South China. Heavy rainfall is received in those regions where the monsoon winds are forced to ascend up steep slopes of mountains or plateaus. Mid-latitude west margin region covers western margins of continents in the westerly wind belt. The coastal region of British Columbia, North-west Europe, South Chile and South Island of New Zealand are examples.

Regions of extremely low rainfall, less than 25 cms. are seen to occur in three regions. The western margins of continents in the trade wind belt form the tropical deserts. South-western United States, Sahara, Arabia, Atacama, Kalahari and Western Australia are examples of such deserts. Interiors of continents in the mid-latitudes form vast deserts such as those of Central Asia, Mongolia and Tibet. Polar regions are cold deserts.

Apart from the variations in total annual rainfall, there are variations in the season of incidence of rainfall. The seasonal migration of pressure and wind belts brings about seasonal variations in the distribution of rainfall. In the equatorial region, temperature remains uniformly high during the year and therefore convectional rainfall prevails throughout the year. There is no distinct dry season in the year. As one moves away from the equator, the total annual rainfall decreases and most of it is received in summer. Winter is the dry season. Rainfall is concentrated in the summer season in the tropical monsoon region also. This is because in the summer season winds blow from the oceans towards the low pressure on the land.

In the mid-latitude west margin region, rainfall is received almost throughout the year owing to the prevalence of the westerly winds which blow from ocean to land. The quantity of rainfall and the duration of rainy season decrease as one proceeds towards the east. South of this region is a transitional belt between the westerlies and trade winds. This region is under the influence of the westerly winds during winter and trade winds during summer. As the region lies along the west coast, westerly winds bring rainfall in winter, while summer is dry. This is the typical Mediterranean region surrounding the Mediterranean sea. Examine your atlas and name the other regions having Mediterranean type of climate.

Weather and Climate

We have examined in the preceding sections some aspects of the physical state of the atmosphere and the changes which take place. Temperature, pressure, winds, rainfall, etc., are various elements of weather and climate. Weather refers to the condition of the atmosphere at a given moment of time at a given place. This is based on observations made either visually or by the use of instruments. Data obtained from several Observatories are plotted on a map to represent weather conditions at a given time. Such weather maps are published in newspapers also. A study of weather maps is the basis for forecasting weather. Thus weather refers to the condition of the atmosphere during a short period of time lasting for a few hours or few days.

Climate on the other hand refers to an integrated picture of weather conditions over a longer period of time such as a month or season. Climate is sometimes referred to as the average of weather, as average values of several weather elements are taken into consideration for purposes of describing the climate. Mean monthly values of temperature, rainfall and other elements are calculated from records relating to a period of at least 35 years. For example the mean rainfall of January is obtained by calculating the average of January rainfall for at least 35 years. Whereas weather map portrays the weather condition at a given time, climatic map shows the condition in a month, season or a year.

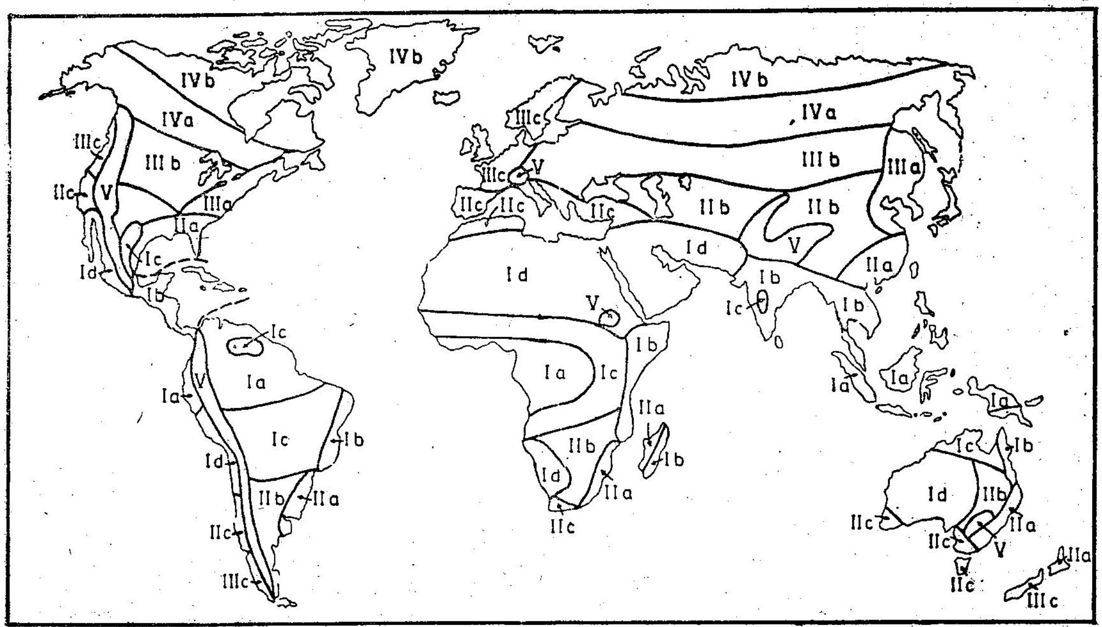

Fig. 9.6

World Climatic Types

Climatic Types

Temperature and precipitation are two main elements of climate. Climatic types are usually distinguished on the basis of variations in these elements. Each one of these elements may be considered first and then the composite picture may be studied. We can distinguish four thermal regions on the basis of variations in temperature. **Hot regions** are those which have a mean annual temperature of over 20°c. These regions are found in the low latitudes. Summers are very hot (more than 30°c) and winters may be hot or warm. **Warm regions** have a mean annual temperature of 10°c to 20°c with hot summers and cool winters (0°c to 10°c). These regions generally lie between 30° and 45° latitudes. **Cool regions** have a mean annual temperature of 0° to 10°c. Summers may be warm (10°c to 20°c) and winters are cold (less than 0°c). These regions occur between 45° and 60° latitudes generally. **Cold regions** with mean annual temperature of less than 0°c occur in the polar regions. The limits between these thermal regions do not coincide with latitudes; they are modified by the land and sea distribution. For example, owing to the warmth of the adjoining oceans, the limit of the warm region extends polewards on the western margins of continents.

Three major regions may be distinguished on the basis of total annual precipitaion. These are (a) Humid region, (b) Sub-humid region and (c) Arid region. Humid region is one in which the annual precipitation is in excess of evaporation. Arid region is one in which the annual precipitation is less than evporation. Sub-humid region is one in which the precipitation is in excess of evaporation during the rainy season only. Thus, these precipitation regions are not delimited by specific values of annual precipitation. As precipitation is correlated with evaporation, effectiveness of precipitation is taken into account. For example an annual precipitation of 25 cm. in a hot region may merit its classification as an arid region, while the same precipitation in a cool region may be more useful and enable cultivation. Besides annual precipitation, seasonal distribution of precipitation is also taken into account for classification of climates. Three categories are recognised. These are (a) rainfall throughout the year, (b) rainfall maximum in summer and (c) rainfall maximum in winter

I. Hot Climates

The Hot climates are delimited by the mean annual temperature of 20°c. This includes the Equatorial region and the Trade wind belt on either side of it. The region does not extend beyond 30° north and south. Four sub-types may be distinguished. These are (a) Equatorial region, (b) Humid East Margin type, (c)Sub-humid Interior type and (d) Arid West Margin type.

(a) **The Equatorial type** - extends roughly between 10°N and 10°S and covers the Congo Basin, the Amazon Basin, Malaysia and Indonesia. Temperature remains uniformly high varying very little according to seasons. The monthly mean temperature is between 25°c and 28°c. Annual rainfall is heavy generally exceeding 200 cm. and is spread throughout the year. Rainfall is mainly of convectional origin and there is no dry season.

(b) **Humid East Margin type** is found along the eastern margins of continents in the trade wind belt. The Monsoon climatic type is also included in this as it has similar temperature and rainfall. regime. The Monsoon regime however has reversal of winds. Besides Monsoon Asia, the Humid East Margin type includes the coast of Central America, Brazil, Queensland coast of Australia, etc. Mean monthly temperature varies from 29°c in summer to 21°c during winter. Annual rainfall varies from 100 to 200 cms. depending on distance from the coast and the presence of relief barriers. Rainfall is predominantly in summer.

(c) **Sub-humid Interior type** occurs in the interiors of continents in the Trade wind belt. The typical regions are the Sudan, parts of West Africa, South Africa, Brazilian plateau and Northern Australia. Mean monthly temperature ranges between 32°c in summer and 21°c in winter. The annual rainfall varies between 50 and 100 cm. with summer as the rainy season. Rainfall decreases with distance from the equator and from the coast.

(d) **Arid West Margin type** extends along the western margins of continents in the trade wind belt. These are the tropical deserts having a rainfall of less than 20 cm. during the year. Mean monthly temperature ranges between 29°c in summer and 10°c in

winter. Temperature may exceed 45°c during day time in summer. Rainfall is highly variable and occurs as a result of local convection. The main regions are the deserts of California and Mexico in North America, Atacama desert in South America, Sahara and Kalahari in Africa, Arabian, Iranian and Thar deserts in Asia and the Great Australian desert.

II. Warm Climates

These climates have mean annual temperature between 10° and 20°c. Summers are hot while winters are cool. The region lies in the transitional zone between the trade wind belt and the belt of the westerlies. Owing to the migration of these wind belts, the region experiences the trade winds in summer and westerlies in winter. Three sub-types may be distinguished: (a) Humid East Margin (b) Sub-humid or Arid Interior type (c) Sub-humid West Margin.

Humid East Margin Type occurs in central and south China, south-eastern United States, southern Brazil, south-eastern Africa and south-eastern Australia. Mean monthly temperature varies between 26°c in summer and 10°c in winter. The region gets rainfall in summer from the trade winds which blow from the adjoining ocean. In winter, depressions associated with Westerlies give rainfall. Annual rainfall may vary between 60 and 150 cms. with maximum in summer.

Sub-humid or Arid Interior Type is transitional between the east and west margin types. Winters are much cooler than along the coast. Rainfall is usually less than 50 cms. during the year though there may be parts with rainfall less than 25 cms. The lowlands of Central Asia around the Caspian and Aral seas and south-western United States belong to this type. The effect of surrounding mountain ranges leads to rainshadow effect.

Sub-humid West Margin Type is known as the Mediterranean type as such conditions prevail in the region around the Mediterranean sea. Other regions having this climate are Central California, Central Chile, Cape Town region in South Africa, extreme southwest and southeast parts of Australia. The mean monthly temperatures range from

10°c in winter to 21°c in summer. Annual rainfall varies between 40 and 90cms. wit h maximum in winter. As this region is under the spell of the Westerlies in winter, rainfall is associated with depressions formed in this belt. Summer is relatively dry as sub-tropical high pressure belt prevails over the region.

III Cool Climates.

Cool climates lie polewards of the Warm climates and are delimited by mean annual temperature of 0° to 10°c. The region experiences warm summers (10° to 20°c) with cold winters (less than 0°c). The region lies in the belt of westerly winds. Three sub-types are recognised. These are (a) Humid East Margin, (b) Sub-humid Interior and (c) Humid West Margin types.

Humid East Margin Type prevails over North Eastern United States and Canada, North China, Manchuria, Eastern Siberia and Northern Japan. Summers may be warm (more than 20°c) but winters are long and cold (less than 0°c). Cold winds blowing from the interior of the continent reduce the temperature. Annual precipitation varies between 50 and 100 cms. with a maximum in summer. There may be slight snowfall in winter.

Sub-humid Interior Type covers large areas in the interior continents of Asia and North America. Temperature values show great variations from mean of about 18°c in summer to —19°c in winter. Winters are long and severe and summers are short. Rainfall is of convectional origin and occurs during the summer. Winter is gnerally dry as the area is covered by vast high pressure. Annual rainfall is generally less than 50 cms.

Humid West Margin Type extends over Bristish Isles and adjoining northwest Europe, west coast of Canada, south Chile and south Island of New Zealand. Westerlies blow over the region throughout the year and as they blow from the ocean, they give precipitation throughout the year. Winters are warmer than usual owing to the warm ocean currents along

the coast. Mean monthly temperature may range from 5°c in winter to 15°c in summer. Rainfall during the year may vary from 75 to 100 cm. or more rainfall is associated with the passage of cyclones in the Westerly wind belt. Maximum rainfall is in winter.

IV. Cold Climates

Cold climates are found in the regions beyond the Arctic and Antarctic circles. Summers are short while winters are long and severe. Two sub-types may be recognised. These are (a) Sub-polar and (b) Polar types.

Sub-polar Type is found along the margins of the polar region in Canada and Eurasia. Extremely cold conditions prevail in eastern Siberia. Winter temperature may be - 40°c. Winter is less severe in the west coastal region. Annual precipitation is about 40 cm. and is derived mainly from convection during summer.

Polar Type includes the area permanently covered by snow and ice. These are the North polar region, Greenland and Antarctica. During the short summer temperature does not exceed 10°c, while in winter, it may be — 30° or — 40°c. Annual precipitation is usually less than 25 cm. This is a cold dry region.

V. Alpine Climate

Exists on the tops of Alps, Himalayas, Rocky and Andies mountains which are always covered with snow.

Climate and Man

Man is both directly and indirectly affected by climatic conditions. Man is unable to bear extreme climatic conditions unless he makes suitable adjustments by clothing or shelter. Woollen clothes are needed in winter to keep the body warm. People living in hot equatorial regions do not need much clothes. Exposure to heat waves and cold waves causes death. Tight fitting clothes are worn by people living in cooler regions, while people living in hot regions prefer loose garments so as to allow circulation of air.

Though man has invented a number of mechanical devices such as air conditioners, heaters, fans, etc., to overcome the hazards of climate, the form of the house reflects the climate of a region. Steeply sloping roofs are found in regions of heavy precipitation in order to drain off the rain water or snow falling on the roof. In deserts houses have flat roofs. In tropical regions, houses with thatched roofs are cooler than those with tiled or concrete roofs. The site, lay-out of the house and the position of doors and windows are all related to climatic conditions.

Climatic conditions govern the type of vegetation and the range of crops which may be cultivated in an area. Each plant needs a definite growing season during which temperature and moisture conditions should be favourable. Climate sets certain limits to the range of crops that may be cultivated in an area, though it does not determine the crop to be cultivated. Thus rice and cotton are tropical crops, while wheat and sugar beet are suited to cooler conditions. The differences in climate provide the basis for international trade in agricultural products. For example, the world demand for tea is met from a few tea producing countries in the tropical region. Similarly pastoral and forest products are produced in climates favourable for the purpose.

Though man has learnt to adapt himself to various climatic conditions, primitive peoples practise a mode of life related to climate of the region in which they live. For example, the pygmies of tropical Africa still live by food gathering and hunting. The nomads of Africa and Asia move with their animals in search of pasture and water. The activities of modern man have also led to the changing climate. The use of coal, oil and other fuels has increased the carbon-di-oxide content of the atmosphere. The emission of smoke from industries and automobiles has also affected the condition of the atmosphere. Man has to adjust himself to the climatic conditions instead of spending huge amounts on making artificial modifications. Climate is one of the elements of the environment which affects various types of human activities.

EXERCISE — 9

Short Answer Questions

1. In what ways is water vapour added to the atmosphere?
2. Distinguish between Absolute humidity and Relative humidity.
3. What causes changes in the relative humidity of a parcel of air in the atmosphere?
4. Distinguish between saturated and unsaturated air.
5. What causes condensation in the atmosphere?
6. Distinguish between fog and cloud.
7. Name three major types of clouds.
8. What causes precipitation?
9. Name the different forms of precipitation.
10. How is orographic rainfall caused?
11. Distinguish between weather and climate.
12. Give an account of Mediterranean type of climate.
13. Describe the main features of Humid West Margin type of climate.
14. Give an example of influence of climate on human activities.

Essay Questions

1. Give an account of the different types of rainfall.
2. Describe the main features of the distribution of rainfall in the world.
3. Explain the basis for classification of climatic types.
4. Describe the main features of Hot climates.
5. Bring out with suitable examples the impact of climate on man.

10. Biosphere — I

In the earlier section (Chapter - 2) we have identified the various elements in the Biosphere. In this chapter, let us understand the characteristic features of these elements and their role in the Biosphere.

We commonly come across the term 'systems' in our day-to-day life. By systems we mean an organized unit with two or more components to carry out a defined function. The earth is such a system where there are many distinct inter-dependent components like the atmosphere and hydrosphere (the non-living environment), plants and animals (the living environment). When living material interacts with the non-living environment a well organized and recognizable single unit is produced namely the biological system or biosystem. Our planet earth is a good example of a biosystem. The working of the system makes the existence of life possible on the face of the earth. This biosystem is able to self-sustain its biological component. The plant and animal cover on the surface of the earth in land, sea and air is known as the **biosphere.**

A study of the biosphere of the earth is important. It receives a continuous supply of solar energy but it cannot exchange its matter with other parts of the universe. Therefore, the quantity of matter in the biosphere cannot be changed but the chemical form and physical location can be changed. Man's activity influences the qualitative nature of the matter in the biosphere and in many cases produces pollution. A clear understanding of the biosphere will help man to keep the earth a habitable place for many more years to come.

We will be using the word component in many contexts. In each it has a specific meaning to convey. We said that in the biosphere there are many components like the many individual parts of a clock. In the biological system we recognize different

levels of organization such as gene, cell, tissue, organ, species, population and community. The living environment is termed as a biotic environment and the non-living as the abiotic (the prefix 'a' gives a negative meaning). The interaction of gene with the biotic components (matter and energy) results in a genetic system and the cell as the cell system etc. We will give some thought to the population system. By population it is meant to indicate a group of individuals of one kind of animals or plants. When population of many kinds of animals and plants live together then the word "community" is used to describe the grouping. Of course the word community can also be used in a wider sense as in the field of Human ecology. The resulting functional unit due to the interaction of community and the abiotic environment is the ecological system or **ecosystem**

The close relationship and dependency of organisms within an ecosystem leads them to interact with each other. They interact either because they are in need of food or to occupy a range of place. When organisms grow and die a cycle of materials (non-living raw material) sets in. Therefore, ecological system or ecosystem is a complex system where there is a constant interaction between organisms as well as with the non-living environment resulting in various types of nourishment levels (tropic levels) and material cycles.

In the ecosystem there is a well defined organization which can be called as the structure of the ecosystem. Six components (parts) make up the structure of the ecosystem. The first component comprises the inorganic substances phosphates, nitrates, water, carbondioxde etc. It goes without saying the next component is the organic substances like amino acids,proteins, lipids and carbo-hydrates. Factors like temperature, rainfall, humidity and climate constitute the third component. The fourth component is called producers which are autotrophic (auto = self; trophic =nourishment) organisms. They are called producers because they trap the solar light energy and produce complex organic substances (food) using simple inorganic substances (component I) through photosynthesis. Green plants, microscopic algae and diatoms are producers.

All organisms do not produce their own food. Those organisms that feed or prey upon others are called heterotrophs (hetero — other). A cow eating the grass or lion eating a cow is an example. These animals are, therefore, also known as phagotrophs (phago — to eat) or macro consumers (macro — large or big; consume — to eat). This is the fifth component. The sixth component is called the micoconsumers. As the very name suggests they are smaller than macro-consumers. Bacteria and fungi are the best examples. When an organism is dead they act upon them and derive their food by passing the digested material through the cell wall. They are variously called Saprotophs (sapro — to decompose) and Osmotrophs (osmo — to pass through a membrane) Components 4, 5 and 6 are living and biological or biotic. They constitute the biomass. Other components are abiotic.

Each of the above mentioned six components, as you can see, is a clear unit by itself but they are all interdependent. One component is a necessary requirement for the other. For example, the microconsumers are important in that they interact with the dead organisms to obtain their nourishment and in that process they set release the bound inorganic and organic components. These two components form the basic raw material for the ecosystem development.

In the beginning of this lesson it was pointed out that two distinct but interdependent components interact to produce a functional pattern of organization. In the ecosystem we could recognize the following six functional categories:

(1) Energy cycles: The solar energy is received by the plants. They produce organic food. Animals directly feed on them by grazing. Thus the energy flows form one trophic level to another. This is termed as a grazing cycle. Animals and plants die decompose. The product of disintegration is known as detritus. Therefore, energy flow through the ecosystem can take two paths: (a) the grazing cycle and (b) the detritus cycle.

(2) Food chain and food web: Animals do not eat all kinds of food. They like some and dislike the other. It is

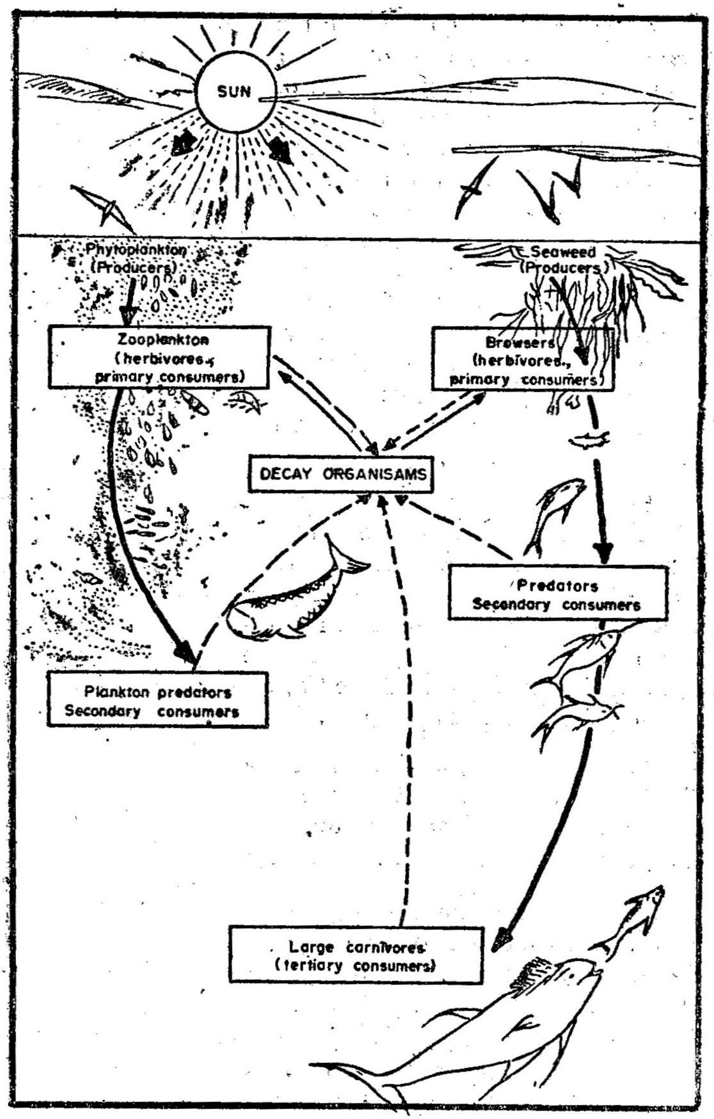

Fig 10.1

Food Web

possible to trace within an ecosystem a definite pattern in the sequence of eating relationship. This prey-predator relationship in an ecosystem is called a **food chain.** Interaction of many such distinct food chains constitute a **food web.**

(3) Animal-plant diversity pattern: The fact that there is interaction between organisms leads to diversity. Some animals and plants are found to inhabit the same region. At certain months or seasons of the year their number and the composition of species may change. As a result we find a definite type of plant animal organizational pattern which differs from region to region and varies within a given area from time to time. The emergence of easily recognizable plant animal diversity pattern is one of the important functional attributes of the ecosystem.

(4) Nutrient or biogeochemical cycles: We mentioned, earlier that with the death of an organism, material cycles are, in a way, set in. The microconsumers like bacteria and fungi break down complex organic substances and liberate the locked inorganic raw materials into the surrounding environment. Such inorganic materials are used again by the plants. The cycle of change continues with quantitative change in space and time.

(5) Development of the Ecosystem: The above functional attributes of the ecosystem show us that the ecosystem is not static but dynamic. Plants and animals interact with each other and with the abiotic environment to set up a well defined trophic level and diversity pattern. The plant nutrients show qualitative and quantitative change in time and space. Such continuous interaction and change contribute to the development of the ecosystem. In a sense an ecosystem is born, grown and matures. In any developing system there are factors that favour or retards development. Such factors are the controlling factors.

(6) Control: The science of control system is called **cybernetics.** Positive and negative controls lead to the stability of an ecosystem.

In the environmental science ecosystem analysis is important. It is the basic functional unit for it shows clearly how biotic and non-biotic environments interact with each other. Such a dynamic state makes life possible on our earth.

Habitat

If some of you want to the catch fish, you are sure that you won't go to the forest with your net. You would go to a pond or a river. This is because each organism lives in a particular place. The physical place where an orgnism lives is the **habitat** of the animal. Broadly speaking the following are the major habitats: freshwater, estuarine, marine and terrestrial. The term habitat conveys a range of meaning. It can be used to describe the living space occupied by an individual organism or an entire community. We can say that algae are found in aquatic habitat. But certain algae prefer small differences in location. The same general large habitat is the macrohabitat and the other a microhabitat. When describing the habitat of an organism or groups of organisms, the word habitat includes both biotic (organisms) and abiotic environment as well. Thus, the habitat of the common water snail is the shallow near shore (littoral zone) vegetation rich pond area. At the same time different species may show some preferences within the broad habitat area. In this sense the habitat includes both the living as well as non-living components. However, a description of the habitat of the community would include only the abiotic environment.

Habitats—Examples

As already indicated, in the biosphere we have the four major habitats namely, freshwater, esturaine, marine and terrestrial. We shall study some aspects of these ecosystem.

Freshwater Habitat

The freshwater habitat can be divided into two divisions: The running water is called the lotic habitat (eg. spring-stream and rivers) and standing water is called the lentic habitat, (eg. lake and pond). When compared to the marine habitat.

freshwater habitat occupies relatively smaller portions of the biosphere. Yet it is important for the existence of man.

Freshwater has many unique proteins. The temperature of the water in a pond does not vary much between day and night. The night temperature of water may be less by 1 or 2°C than the day temperature. This is due to its high specific heat which does not allow water temperature to rise suddenly. Secondly, at 4°C water has its maximum density a property which prevents total freezing of water into solid ice in aquatic habitat. There are other termal properties that favour growth of organisms. A body of water may become turbid as a result of living organism or fine sand particles called silt and clay. The extent of turbidity is measure of the water quality and inversely related to the light penetration. The quantity of gases and salts and plankton (floaty organisms) is also controlled by currents. In the freshwater ecosystem there are autotrophs (producers) phagotrophs (macro-consumers) and Saptotrophs (decomposers). The freshwater lake has the following zones: the area near the shore is called the Littoral zone, the upper layer which is lighted due to light penetration is called limmetic zone and the bottom — the less lighted zone is the profundal zone. In each of these zones we have a particular type of plants and animals.

We can study the freshwater from many points of view. Linology is the study of physical and chemical aspects to freshwater in relation to biology and geology.

Marine Habitat

The study of marine habitat is important because 70% of the biosphere is coverd with sea water. The sea is deep and there is a diversity of environment on it. The deep layer has total darkness and life is much lesser in this region when compared to the edge of the sea—the shore area. The sea extends from pole to pole of the biosphere and forms a continuous body of water. Therefore differences in temperature and salt content of the seas not only play a great role in the distribution of organisms but also set the sea water in continuous circulation.

The region near the coastal margin is characterised by waves and tides. Further we see periodically the sea level rising and falls. The rise is called a high tide and the fall — the low tide. In each locality high and low tides occur twice daily. The tidal difference between high and low tide varies between 1 foot to about 50 feet depending upon the locality. In sea water there is greater amount of dissolved salts. The salt content is termed as salinity and expressed with a symbol of o/oo. Normally the salinity of sea water is 35°/oo (35 parts per thousand grams or per kilogram). The sea water is alkaline in nature and the pH (Hydrogen ion concentration) is normally around 8. The carbon dioxide system, of which we made mention earlier, keeps the sea water from sudden changes in pH values. This property helps many different types of organisms to grow. As a result the diversity and abundance of organism is greater in sea water than fresh water. In both the aquatic habitats—freshwater and marine—bacteria, algae, green flagellates and copepods play an important role. Animal phyla such as coelenterates, sponges, echinoderms and annelids are either totally absent or poorly represented in freshwater habitat, and the diversity of algae, crustacea mollusks and fish are greater in the sea.

In the neritic zone (known as intertidal zone) organisms that float on the surface are found. They are called the **plankton** meaning wanders. They are at the mercy of waves and currents. Animals with power of swimming are called the **nektons.** As in the freshwater ecosystem, phyta planktons are the producers and nektons are the macroconsumers (fishes). Marine microorganisms complete the energy transfer cycle.

Terrestrial Ecology

Terrestrial habitat presents diversity of land forms. When compared with aquatic ecosystem there is less diversity in the organisms present in this area. In the terrestrial ecosystem organisms face the problem of dehydration. Transpiration of water from the leave's surface is the characteristic feature of the land plants. There are extreme variation in temeperature between day and night. Land, unlike the ocean, is not continous. Soil

provides good support for organisms. Both plants and animals of the terrestrial ecosystem have developed strong skeletal support and special means of locomotion for life on land.

The characteristic feature of land communities is the presence of vegetation a term which includes all green plants. As in other habitats green plants are the autotrophs which are the producers. Since terrestrial ecology is so varied there are also various types of plants that have adapted to specific type of environmental gradient. Plants that grow in wet area are called **hydrophyte;** those in moist area—**mesophyte**, those in dry are—**zerophyte** and those in salt area—**halophyte.** Insects, large herbivores like the hoofed mammals are important members of land consumers. Bacteria, fungi, protozoa and other invertebrates are the chief saprotrophs or microconsumers. These decomposers are present in the uppermost soil layers and play on important role in the transfer of organic matter to the soil. Humas is an important source of enrichment of nutrient to the soil.

In the terrestrial environment regional climates determine the type of organism that can live in any one specific place. Such interaction between climate and biota of a region produce large easily recognizable community unit called biomes. The Biomes is the largest land community unit with uniform life form of the climatic climax vegetation. On this basis we can distinguish grassland community (biome) deciduous forest biome, Tundra Coniferous Forest biomes, moist temperate (Mesothermal) coniferous forest biome, evergreen subtropical forest Biome, Tropical Savanna biome, Desert biome, Pinon Juniper (Pigmy Conifers) Biome and tropical rain forest Biomes.

Ecological Niche

The study of ecosystem has thrown open many new ecological concepts. One such recent concept is the ecological niche There are three major aspects. The interaction of organism brings about a distribution pattern. As a consequence animals

inhabit certain range of area which we have called the **habitat**. A knowledge of the habitat of an organism is important in the understanding of the funcional role of an organism in the ecosystem. This functional role of an organism is its **ecological niche** The niche of an organism includes both the specific habitat as well as ts functional role in the ecosystem. We have now mentioned two aspects. the habitat and the functional role. The former-the knowledge of the habitat - is the **habitat niche** and the latter is the **trophic niche.** We have noted earlier that the word trophic indicates nourishment levels. Organisms obtain their food by autotrophic or heterotrophic mode of nutrition. If one gets some information on the way the animal feeds or the type of food eaten and the particular adaptions such as the length and breadth of the bill in birds, then he can have a good understanding of its functional role which we call the **trophic niche.** Take for instance, the place where you live. There are people in your place who produce food and others buy it. Scavangers remove the waste matter and micro organisms do the act of decomposition. Each one is carrying out a certain function and the community functions well. People live in such a condition. Likewise in a biotic community plants take up the functional role of food production. They are primary producers. Macro consumers like cow graze the grass and lions prey upon them. Vultures and foxes live on the dead. remains left by the macroconsumers. Finally bacteria and other micro organisms decompose and break down the organic matter into raw materials. An organism not only lives in habitat but a type of environment surrounds it. The term **multidi mens onal niche** is used to denote the totat environment that surrounds an organism.

The niche of a given species in a given ecosystem is not the set of conditions that would be best suited to the genetic make-up of the organism, but rather it is the best accommodation that the oranism can make to the realites of its environment.

Overlap and Diversity of Niches

Let us imagine a flood plain surrounded by swamp on one side and mountains on the other side. There are two tribes viz.

A and B of nomadic hunters living in this area. Suppose the best hunting grounds are found along the flood plain of the river. It is a well known fact that both the tribes will try to utilise this plain as their prime hunting area. The net result is that the tribe A and B would maintain different secure territories on the edge of the flood plain. Thus we have two home bases viz. tribe A home base at the edge of mountain and tribe B home base at the edge of the swamp. The hunting area that lies between these two bases will be visited by both the tribes. If the tribe A had the opportunity of solely possessing the land, the people of this tribe could be fed easily from the population of the low land animals. Here the tribe A have to face the stiff competition from tribe B. Therefore the hunters of tribe A is forced to hunt in the adjoining mountainous area. Consequently the hunters of tribe B have to search their food around the swamp area near the vicinity of the home base of B. Let us say that there is going to be fire, which destroys the low land hunting areas. Then both the tribes have to search for alternate sources of food and feed their people.

In other words, here the competition between animal species can be considered anaglogous to the competition between the two tribes. For example let us replace the term home base and tribe by niche and species. Then we get the good example of a simplified case of competition between the animal groups. Thus we can imagine that if the niches for two separate species were identical, competition for food and shelter would be particularly intense. Several authors of ecology have given concrete proofs to show that the two species in the same ecosystem cannot both survive in the same niche. This in turn has given a new concept explaining that in "an ecosystem which houses many species, not only is the diversity of niches very large, but species are co-adapted to overlapping niches so that elimination through competition is reduced. It is also observed that these niche interactions result in the migration of species or animals from one area to another. This can be illustrated from the following exmple. In Africa we have two type of grazers viz. Zebra and Thomson gazelle. Zebras are large, horse-like animals, which do not chew their cud. Where as the gazelles are chewing animals and hence their physiology system is different than that of zebras.

Thus the zebra is able to eat large quantities of food and excrete unnecessary carbohydrates. It can live on plants with low protein content. But the gazell cannot eat such large quantities of food and therefore it has to live on protein rich grasses. Now, during the wet season both the animals graze together on the hill sides. As soon as the drought season arises, Zebras cannot subsist on the sparse growth, with the net result, they move to flood plians. The gazelle remains to move in the hillsides consuming protein rich small grasses. No doubt after some time the gazelle have to move out in search of food. By this time the zebras have cut the tall grasses in the flood plain leaving shorter grasses. Then gazelles move again to flood plain to consume those small grasses.

The niche of an organism may not be same for given length of period. For instance a bear in the forest can eat the grass and show the features of a herbivorous animal. But at certain times it can catch a fish and eat it. It is quiet evident that a niche of an organism may change.

In the biosphere there are types of ecosystem. We can study the concept of ecosystem by taking the following as ecoysystem, the river, ponds, aerodrome, meadows, playgrounds, and the spacecraft. Now let us take pond as an exmple. In the pond water one can find both organic and inorgnic substances. The climatic regime has a great influence on the quality and quantity of water. There are plants that are both rooted plants and floating microscopic plants. Among the rooted plants some plants project their leaves outside the water (cat tail **Typha**) and others are rooted but float their leaves like water lily **(Nymphaea)**. While others are totaly submerged like the muskgrass **(Chara)**. Aquatic insects, mollusks, crustaceans, annelids and fishes form the macro consumers. Among the saprotrophs, the water becteria and fungi are of importance in reducing the organic matter to inorganic form. On the basis of this analyses you can choose another habitat and do a comparative study.

EXERCISE—10

Short answer questions :

1. How is a biological system or biosystem produced?
2. What are the different levels of organisation in the biological system?
3. How is the term communinty used to represent population system?
4. Mention the six components that make up the structure of the ecosystem.
5. Explain Food web.
6. Explain the term habitat-Give examples.
7. What do you mean by trophic niche and multi-dimensional niche.

Essay questions :

1. Explain the concept of ecological niche with suitable examples.
2. Bring out the difference in the characteristic features of the marine and freshwater system.

11. Biosphere — II

Biogeochemical Cycle

We noted earlier that chemical elements form one of the important component in the structure of the eco-system. Plants need them for food production and growth. The cycle of events starting from the utilization of the raw inorganic chemical elements, commonly known as plant nutrients, by the autotrophs to their return to the environment due to action of micro-consumers (bacteria and fungi) are known as **biogeochemical cycles** Since the chemical elements are also involved in the nutrition they are known as nutrient cycle. Out of the 90 elements known to occur in the environment about 40 are known to be required by living organisms. Elements like carbon, hydrogen, oxygen and nitrogen, are needed in large amounts whereas substances like nitrate-nitrogen, phosphate-phosphorus and silicates are required in trace (small) quantities. All of these chemical substances show a clear biogeochemical cycle.

"Bio" refers to living orgnisms and "Geo" refers to the rocks, water, etc. of the earth. The discipline of geo-chemistry deals with the study of the chemical composition of the earth and with the exchange of these elements between different parts of the environment. The word biogeochemical cycle, thus refers to the exchange (back and forth movement-flux) of materials between living and non-living components of the biosphere. Each chemical element in its cycle has two parts or pools (a) a reservoir pool and (b) a cycling pool. As their names suggest, the reservoir pool is generally non-biological component as it is slowly leached out from the earth crust. Whereas the cycling pool indicates exchange of mateial between organism and the ambient environment. Further some of the chemical substances are gases in nature (e.g. nitrogen) and others are sedimentary (e g. phosphorus). To the organism only the cycling pool of nutrient is a readily available. In nature, the reservior pool of some cycles like carbon dioxide or oxygen is much larger so that any gross

alteration in the cycling pool will be quickly self-adjusted. On the contrary, in the sedimentary cycle involving elements like phosphorus quick self-adjustment is rather belated due to the fact that most of the reserve of phosphorus is found deposited, in an inactive state in the earth's crust. An understanding of the cyclic pathway of these chemical substance is important since they act as a controlling (limiting) factor in the distribution and abundance of arganisms and play a major role in the industrial air pollution.

Carbon Di Oxide (CO_2) Cycle

The atmosphere serves as an active reservoir source of CO_2 even though it constitutes only about 0.03 per cent of the atmosphere by volume. A good portion of carbondioxide is found in sea water in a bound form as carbonates.

Plants need carbon di-oxide to manufacture sugar (carbohydrate food)

Photosynthesis

$$6\,CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

Sugar (carbohydrate food)

The stored food is 'burnt' (used) inside the cell to obtain energy (cellular respiration) and CO_2 is released.

Respiration

$$6\,O_2 + C_6\,H_{12}\,O_6 \longrightarrow 6\,CO_2 + 6H_2O$$

The balance of CO_2 cycle, on one hand, depends on biotic components. Less than half of the total carbon cycling occurs through biological and other organic pathway. Man's agro industrial activity adds significant amount of CO_2 into the atmosphere. Such atmospheric CO_2 dissolves readily in sea water as follows.

$$CO_2 + H_2O \rightleftarrows H_2\,CO_3 \rightleftarrows H\,CO_3 \rightleftarrows CO_3$$

Thus a state of dynamic equilibrium is brought about. In this state, atmospheric CO_2 is constantly being dissolved into the ocean while some amount of already dissolved CO_2 escape from the sea to the atmosphere.

This geochemical cycle, although independent of the biotic environment, is closely related to the mineral meta-bolism of organisms. The conversion of CO_2 into carbonates results in their settlement in the form of calcium carbonates (limestone). Marine animals use calcium carbonates for their skeletal (eg.shell) production. Skeletons of various forms of sea organisms is another source for limestone deposit.

It has been estimated that 8 billion tons of CO_2 are annually released into the atmosphere due to man' s agro-industrial activity by burning fossil fuels and intensive cultivation of land for agriculture. The intensive and frequent ploughing of soil enhances the release of CO_2 from the soil. It is known that such a change has resulted in the decline in the amount of certain trace elements in the soil due to the reduced flow of CO_2- charged acidic water resulting in the decreased rate of dissolution of these elements from their rock deposits. In other words man-made perturbations would affect the flux (exchange) between the reservoir pool and the cyclic pool. Further the increased use of fossil fuel and the removal capacity of the "green belt" of the biosphere will affect the atmospheric compartment resulting in climatic changes.

Oxygen Cycle

In the environment oxygen is present in many different conditions; it is present in the gaseous state as molecular oxygen (O_2); or component of an inorganic chemical substance (H_2O)or organic substances ($C_6H_{12}O_6$). As mentioned earlier plants use carbondioxide and release oxygen as a by product. During the cellular respiration oxygen is used to form water and carbondioxide is discharged. In the economy of living oranism these byproducts are reused as raw materials.

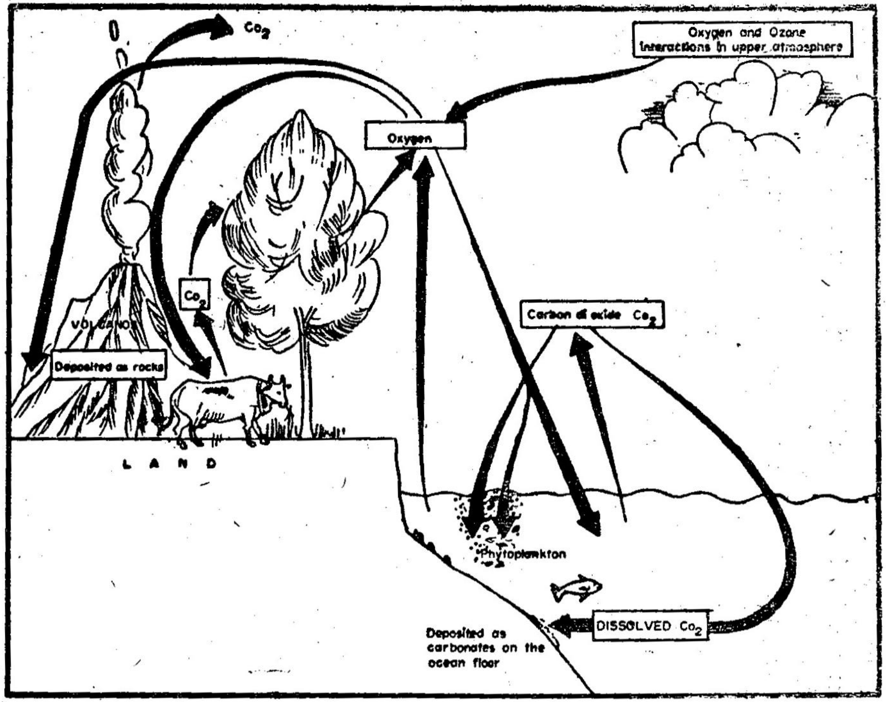

Fig 11.1 **Oxygen—Carbon Cycle**

Hydrological Cycle

It is known that about 70% of the earth's surface is covered with water (Hydrosphere). Water, like other chemical substances is in a state of flux. The content of water in the atmosphere is small about 0.13 geograms (10^{20} grams) and it remains in the atmosphere only for a short time. The Lithosphere contains water as ground water. Major portion of water is contained in the sea. Some amount of water is found in ice caps and polar seas. Evaporation and rainfall bring about a water cycle on a global scale. In this cycle more water is evaporated from the sea but less amount of water is returned by way of rainfall. On the otherhand, the amount of water evaporated is small but return of water via rainfall is more.

Nitrogen—Nitrate Cycle

The nitrogen-nitrate cycle is the best example of a very complex gaseous type cycle that is related to nutrition of plants. Nitrogen and oxygen occur in the ratio of 4:1 in the atmosphere and so serve as the greatest reservoir. However most of the organisms cannot utilize atmospheric nitrogen directly. Various biological and physical factors modify atmospheric nitrogen and present it in a form that can be utilized by plants. Lightning and photo-chemical actions fix atmospheric nitrogen as nitrates. When animal and plant protoplasm is broken down to inorganic substances the nitrogen released by the denitrifying bacteria enters into atmosphere. Those bacteria and algae that convert atmospheric nitrogen into nitrates are called **nitrogen-fixers.** Such nitrogen-fixing bacteria and algae are important since the availability of nitrates control the synthesis of protein. In nature the conversion of nitrogen into nitrates takes place in many steps involving many types of bacteria and other organisms. A group of bacteria converts nitrogen (N_2) into ammonia (NH_4). They are called the aminifying bacteria. Those bacteria that convert ammonia into nitrites are called **nitrite bacteria.** The nitrite bacteria convert nitrite to nitrate, Some plants are able to fix nitrogen with help of bacteria that live in association with them. Such mutual help by way of association is called symbiotic associations. Legumenons

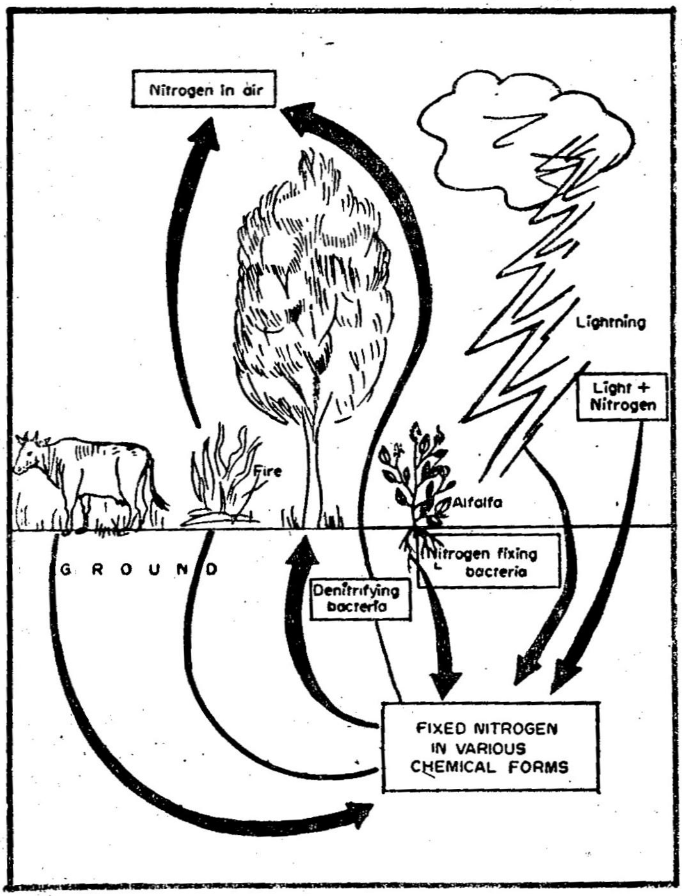

Fig. 11.2

Nitrogen Cycle

plants are the best examples. Nitrogen fixing bacteria associated with legumes are of high importance in modern agriculture.

Phosphorus Cycle

The phosphorus cycle is a good example for sedimentary type. Plants utilize phosphorus as phosphates and phosphate rocks and fossil-bone deposits are the rich reservoir pool. By erosion phosphate is leached and found dissolved in aquatic medium. Excretion of plants and animals and decomposition of organic matter are other sources of phosphates in the dissolved state. Since phosphates are important chemical substance in the protoplasm and genetic materials, the quantitative and qualitative change in space and in time control the abundance and distribution of organisms. For instance in the marine environment when phosphates are more in concentration, photo-plankton appears to be less abundant. Further amount of eroded phosphate from rock deposits is much greater than the amount of returning phosphate. Sea birds play an important role in returning phosphorus to the cycle e.g., the famous guano deposits on the coast of Peru. Thus sea birds are important link in the renewal of phosphates on land from sea.

Sulphur Cycle

Sulphur, like the nitrogen, is an essential component of organic matter. In some amino acids sulphur is an important constituent. Soil and sediments serve as a reservoir for large amount of sulphur than the atmosphere. Fuel combustion is a source of SO_2 to the environment which can be absorbed directly by plants and dissolved in the aquatic medium. In the soil and sediments anaerobic respiration of bacteria reduce SO_4 to H_2S gas which can rise to shallow sediments where it can be acted upon by other organisms. Therefore, specialized bacteria bring about chemical oxidation and reduction of SO_4 to H_2S. and vice versa. The amount of SO_4 available for incorporation by plants into proteins is dependent upon erosion, sedimentation, leaching, rain and absorption-desorption process at the air, water and soil areas. Sulphur cycle is a good exmple to illustrate the interdependence of air, water and the soil.

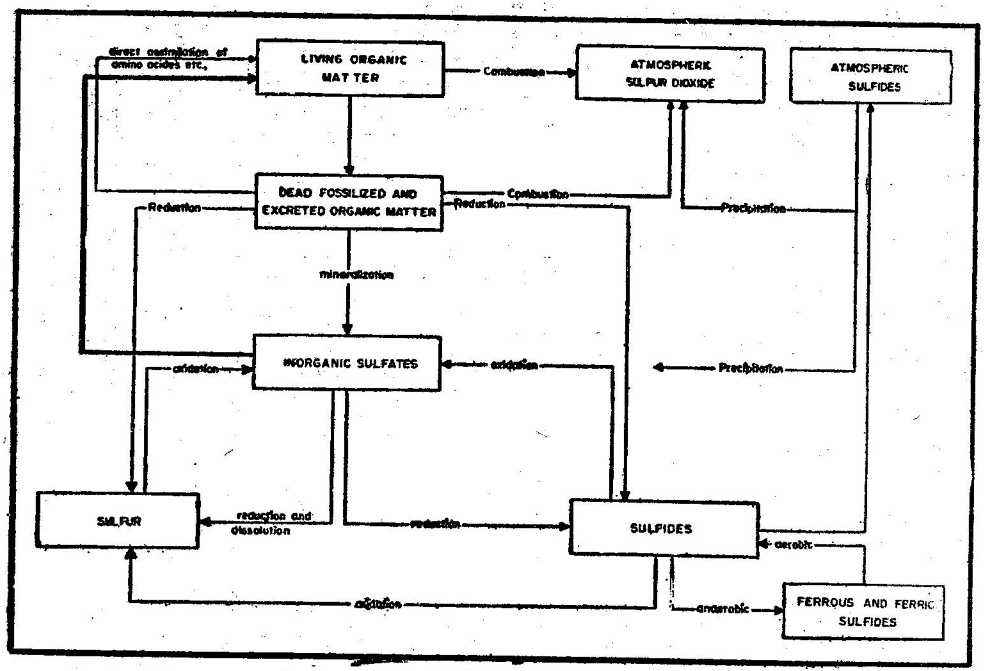

Fig. 11.3 **Sulphur Cycle**

Further the formation of iron sulphides in the sediments helps in the conversion of insoluble phosporus to soluble form (See Figure 11.3).

Man's Impact on Biosphere and Biogeochemical Cycles

Man is an unique creature of this biosphere. He is not bound, in a sense, by the general principles of environmental sciences because of his flexibility and adaptability of behaviour based on reasons and his ability, to control his own immediate environment by his technological ability. So important is the man's role in the ecosystem that he is now the hub on which the future of the biosphere depends. He has rightly been called "a mighty geological agent" a statement that underlines his modifying ability, to the better or worse, of the ecosystem.

The population of man is steadily increasing. It has been estimated that by the year 2000 A.D. it would have reached a mark of 6.5 billion. More people means more living space and more food. Man is now expanding his agro-industrial activities to cope up with the increasing demand. He is using more of fossil fuels (coal and petroleum). He is speeding up decomposition rate of human by his agricultural practices. We have noted that frequent ploughing of the soil results in the imbalance of CO_2 which has an effect on the rate of release of mineral deposits. Further continued injection of CO_2, due to man's activity, into the atmosphere will affect the climatic regime of the biosphere. The so called "green house effect" will set in. This means that an increase in CO_2 content in the environment increases the temperature of the entire biosphere. As a result the polar ice caps will start melting leading to a rise of about 400 feet of seawater. What a catastrophic effect that awaits us if man is not temperate in his activities and outlook.

Man uses DDT to kill the pests that destroy his agricultural fields It gives us enough food to eat. But what are the long term effects. DDT (Dichloro Diphynl Trichomethane) has been used for insect control. DDT after killing insects remains toxic for long periods of time and gets absorbed on detritus

material. Small fishes that feed on detritus keep accumulating these DDT residues. As a chain reaction DDT keeps accumulating in its magnitude at each trophic level. Finally when it reaches man, it produces all types of health hazards. It has been proved that DDT interferes with the egg shell fromation. When adult birds sit on eggs to incubate them, the egg shell cracks, not being able to bear the weight of the mother bird. Just imagine if such ill effects keep reappearing, a whole species of birds may go out of existence. Who is responsible? Will man owe his faults?

Similarly man's increased activity in using fossil fuel has affected the biogeochemical cycles on one hand and on the other, affected his own health. Coal burning and automobiles introduce oxides of nitrogen (NO_2. NO_2 and SO_2) into the environment. Both NO_2 and SO_2 are harmful to plants and man. SO_2 does not allow plants to carry out photosynthesis and therefore, they die. Similarly NO_2 causes respiratory diseases in man and animals. Further NO_2 combines with unburned hydrocarbon from the automobile exhaust to produce a toxic substance commonly known as "photochemical somg" which causes eye irritation and eye-watering. Nitrogen oxides + Hydrocarbon ——————→ Sunlight (Ultra violet radiation) Photochemical Smog + Ozone (O_3) (Peroxyaetylc nitrate).

Some of the so-called natural disasters may be directly related to man's activity and his efforts to bend nature for his own benefit. The biosphere will continue to be a place with balanced biosphere only when man owns his responsibility and puts control on his activities that upset the structure and function of ecosystem. Man's efforts to domesticate animals, interference into the recycle pathways, industrial and green (agriculture) revolution has in fact resulted in vast destruction of productive soil and vegetation. Widespread destruction of the biosphere can be averted only if when human population and his agro-industrial activites are kept under control.

EXERCISE — 11

Short answer questions :

1. Define bio-geochemical cycle.
2. How are carbohydrates produced ?
3. What is an oxygen cycle ?
4. What are nitrogen fixers ?
5. Explain the term symbiotic associations. Give examples.
6. What is the function of a phosphorous cycle ?
7. How is sulphur cycle a good example to illustrate the interdependence of air, water and soil ?

Essay questions :

1. With suitable examples explain the role played by bio-geochemical cycle with biosphere.
2. "The nitrogen-nitrate cycle is the best example of a very complex gaseous type cycle that is related to nutrition of plants" — Discuss.
3. Bring out the impact of man on Biosphere or on biogeochemical cycle.

12. Resources

Meaning and Nature of Resources

Resource literally mean 'a source of supply, support, or aid, especially: one held in reserve'. It refers to all those aspects of man's environment which can be used for the satisfaction of human needs and desires. It may include all the material components of the environment (both mass and energy) if these components can be used by man for satisfaction of his needs for food, shelter, warmth, transportation and so on. If these components cannot be used for satisfaction of human needs, they cannot be regarded as 'resources'. Petroleum, for example, had little value before man learnt to use it for human welfare. Earlier it was regarded more a nuisance as a contaminant in the wells rather than a resource. Thus any component of environment can be regarded as a resource only if it can be used for human welfare.

Resources can be classified in various ways. Depending on the nature of availability, resources can be divided in two broad categories: renewable resources and non-renewable resources. Renewable resources are those which may be used again and again without getting exhausted, like water power and solar energy. These are also known as flow resources as they continue to be available endlessly. Non-renewable resources are those materials which are limited in nature like coal and iron ore. The formation of these non-renewable resources is so slow that the limits of supply can be regarded as fixed. A broad classification of resources has been given in Table 12.1.

TYPES OF NATURAL RESOURCES

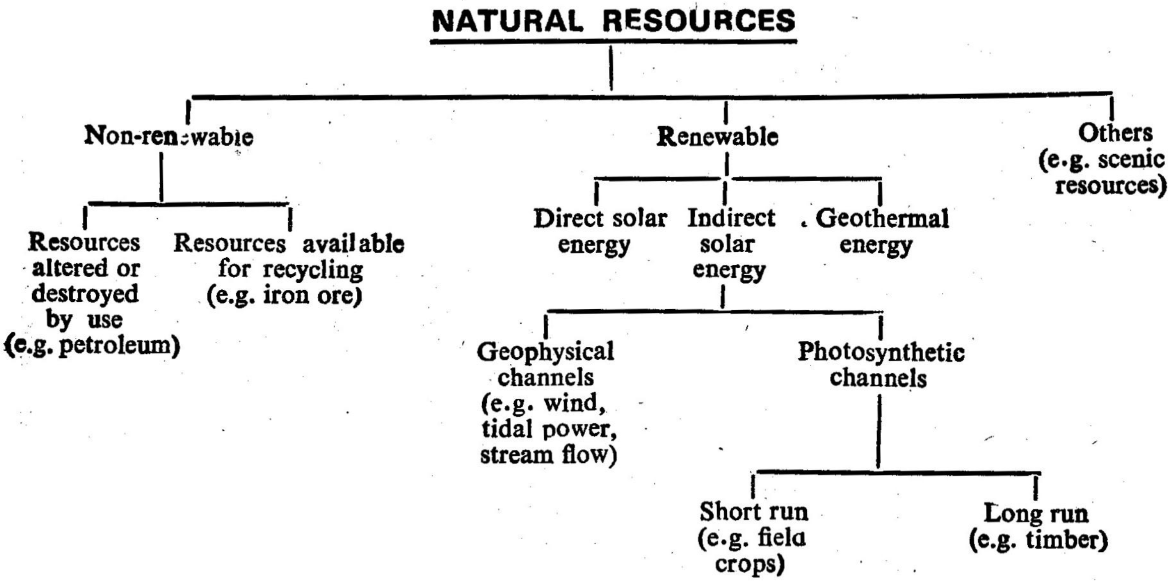

Table 12.1

The renewable resources can further be divided in two groups: first, those resources whose levels of flow are not affected by human action like tidal energy; and second, those resources whose levels are affected by human action like ground water. As we well know, ground water resources can be reduced singnificantly or even permanently by overuse. In many parts of India, groundwater resources have been reported to be diminishing and posing problems for the irrigation tubewells.

Resources can also be classified as natural and human resources. Natural resources are all those resources which have been made available to man through the bounties of nature. These usually include land resources, water resources, mineral resources, energy resources, and biotic resources. Human resources, on the other hand, refer to the number and quality of people, their ingenuity and skills considered as real assets. Man, of course, is very vital element in the resource process. He is the creator and destroyer of resources as also the consumer and beneficiery of all resource endowments.

The concept of resources is a dynamic one. Resources are subject to continuous change and constant evolution. Natural resources themselves are highly variable in time. They may be in abundance at one time and in acute shortage at another time. Occurrence of frequent floods and famines, caused by abundance and scarcity of water respectively, is an example in point. Resource exploitation and degree of technological development are equally variable. Inventions and discoveries may change the very nature of the resource endowments of a region. Materials once thought to be useless may come to be the basis of an entirely new industrial development. The sandy stretch of the Thar desert in Ganganagar district of Rajasthan was considered to be useless before the introduction of canal irrigation. The irrigation has ushered in a new era of property in the region and the same sandy stretch is yielding bumper crops now.

Limited Reserves of Resources

As mentioned earlier, man is the vital factor in the concept of resources. He is the consumer-beneficiery. World population

of this consumer-beneficiery has increased tremendously over the years. It was estimated to be about 500 million in 1650, 1000 million in 1850, 2000 million in 1930 and 4000 million in 1975. Thus the world population has doubled in 80 years between 1850 and 1930 and in only 45 years between 1930 and 1975. The present expansion of population by 2 per cent per year is alarming. It is estimated that by the turn of this century (2000 A.D.) the world population will touch the 7000 million mark. Each human being will require basic necessities of life such as food, water, shelter and space. As the living standards rise, the per-capita demand for resources, too, is growing. All this demand is being met by a massive consumption of natural resources.

The combined effect of increased population and percapita resource consumption has resulted in a four-fold increase in resource extraction in the last 100 years. The amount of most of the metals and ores used since 1930 is in excess of the combined demand of all previous centuries of human usage. It is estimated that by 2000 A.D. the world will need a tripling of aggregate food output, a five-fold increase in energy, a five-fold increase in iron alloy and a tripling of lumber output. Thus, there is a great need for careful utilization and conservation of the non-renewable resources if we want to save the future generations from disaster.

In many areas soils are being depleted because of overeuse, erosion or waterlogging. Over grazing of pasture lands, indiscriminate deforestation and cultivation of marginal lands have created ecological imbalances. Indiscriminate encroachment on farm land for urban needs has resulted in shrinkage of agricultural land. Appropriate and immediate measures have to be taken to arrest these trends to improve the quality of human life.

Land and Soil Resources

Natural environment is especially significant to man as it provides most of the raw materials and energy for human sustenance. It also sets forth certain conditions with in which

man's economic activities can take place. Land is an important component of this natural environment.

Land refers to the surface forms of the outer crust of the earth's solid portion. It is of great importance to human beings because much of human activity takes place on the land surface, and most of the food required for human sustenance is grown on land. The quality of land, its slope, ruggedness, and fertility, greatly influence the life pattern of a people. Land rescources broadly include all those features and processes of land which can, in some way, be used to fulfill certain human needs. These may include resources of very stable nature like land forms, resources of moderately stable nature like soils and resources of relatively unstable nature like vegetation and biological features.

Land is made up of rocks which in turn are made up of different minerals. Rocks are thus the foundations of land forms and repositories of minerals. Rocks have been classified by genesis as igneous, sedimentary and metamorphic. It is the disintegration of these rocks due to weathering and erosions that produces soils.

Landforms differ in relief (the difference between the lowest and highest elevations) and configuration (the arrangement of terrain). Three major categories of land forms are usually identified : the plains, the plateaus and the hills and mountains. A plain is sizeable land surface of flat to gently undulating terrain. Most plains are low in elevation but high plains also exist. A plateau is a flat or slightly irrigular surface of high elevation and appreciable extent, usually bounded by steep slope on one or more sides. Hills and mountains are landforms of appreciable slope and of small summit area.

All these land units have been inhabited by man in varying degrees. The plains have been by far the most favourite areas of human settlement because of the flat ground and fertile soil cover. The great continental plains of Eurasia, North America and South America are all inhabited and utilized by human population. Most of the river valleys and associated plains have

been densely inhabited and intensively utilized by man. Great human civilizations in the past have sprung and flourished in the river valleys of the Yangtze, the Indus, the Tigris and Euphrates, the Nile and the Po.

Landforms have an indirect as well as a direct impact on human activity. They greatly influence the other environmental features which in turn are important to human activity. Mountains, for example have great impact on climate. Natural vegetation and soils are affected by landforms directly through slope and drainage as well as indirectly through climate. Climate, vegetation and soils are the three important factors of natural environment which man must cope directly in earning a living.

Soils

Soils are vital to human life as about 90 per cent of man's food is grown on soils. Soils form the outer cover of the land areas and act as medium through which plant life is joined, physically and physiologically, with the earth's land surface, soil, in other words, is the loose land surface material in which vegetation can go. Genetically, soil is the result of a slow admixing of critical organic and other materials derived from surface life, with equally necessary minerals and other materials originating in sub-surface rock-strata. The slope and the rock structure are important elements in soil formation. Climate is significant both directly and indirectly. It sets temperature and moisture limits to certain types of plants, provides precipitation responsible for much of water action, and acts in diverse other ways. There is a general association among the broad climate, vegetation and soil regions of the world.

In areas where climate permits agriculture, the natural fertility of soils becomes very important. Of course, it may be argued that soils act only to support plant life, and fertilizers and manures can be added to the soils to provide the necessary plant nutrients. Still, we should not lose sight of the fact that over greater part of the world and with over-whelming majority of the world population, agriculture is at the subsistence level and it may not be possible to afford fertilizers and manures in large amounts.

As a component of nature, soils are not exploited directly by man; they supply directly no raw materials for consumption and production. Instead, they constitute one of the most important series of natural conditions with which man must cope in gaining livelihood.

About one-half of the arable land of the world is owned by three nations, the Soviet Union, the United States and India. The first owns about one-fifth of the world total, the other two approximately one-sixth a piece. Communist China is next with about one-twelfth, the remainder of the world's political units are much less favourably endowed.

Of these four nations, the Soviet Union is hampered seriously by both cold and aridity in its attempt to expand the farm area. India's soils have been depleted by overuse over the centuries and there is also moisture deficiency and excess in certain areas. Still the soils have been fully exploited and the soil productivity is fairly high The soils of Communist Chnia too have been depleted by overuse. Of all the nations of the world, United States possesses the largest amount of naturally excellent farm land.

Eventhough soils are so very vital to human existence, they have not received the necessary care and attention of man. In many areas soils are being impoverished because of soil erosion, overuse or water logging. If unattended, these problems will attain serious proportion in future.

Mineral Resources

A mineral is a natural element or combination of such elements with a specific chemical composition and usually a definite molecular arrangement. Some minerals occur as single elements whereas some others occur as combinations. They are usually in solid form but can also be found in gaseous and liquid forms. Most of these are inorganic, but some may have been derived from the decay or alteration of organic materials.

A mineral resource is a mineral supply capable of exploitation. Whether and to what extent a mineral can be exploiated depends upon its quality, quantity, and accessibility, as well as upon current technological and economic conditions and arrangements. About two hundred minerals are now classified as economically exploitable.

Of the more than 1,600 minerals now recognised, only about 50 are classified as rock-making. Most of the remainder, while occurring in rocks, are injected into crevasses, fissures, etc. Rock structure is so complex that it would be difficult to relate specific minerals to specific rock types. Most of the metallic minerals, however, appear to be related, directly or indirectly, to igneous and metamorphic rocks.

Most minerals are too poorly represented in the earth's crust — so poorly, in fact, that the exploitation of certain desired minerals may not be commercially feasible at a given time. To be exploitable, minerals must be in concentration, the actual degree of concentration necessary depends upon the substance being sought; for example, shallow ores containing one per cent of metallic copper are now mined profitably whereas materials containing 20 per cent or less of iron ore are now generally considered too lean for exploitation.

Nature's bounties are very unevenly distributed over the earth's crust whether we are concerned with soils, vegetation, animal life, minerals or other natural resources. Mineral resources are particularly erratic in their distribution in localities, in states, in continents and in the world.

Because of their significance in economic well being of people, minerals are vital ingredients of econmic and political power. Control over their reserves is achieved and maintained most easily when they are located within the boundaries of an exploiting nation. Consequently, areas of known mineral wealth are coveted by all nations and sometimes actually become political pawns. The petroleum deposits on the borders of Iraq and Iran are good examples in point.

Energy Resources

Energy constitutes one of the most important resources of man. Energy is needed for transport, industries, and modern agriculture. As a matter of fact, consumption of electric power per capita is one of the most potent indicators of development.

A recent survey by the United Nations indicates that the total world consumption of energy amounts to the equivalent of nearly 5,000 million metric tons of coal and that it is increasing at the rate of 5 per cent per year. More than one-half of this energy is believed to be used in manufacturing, one-fifth in transportation, one-fifth in domestic heating and the remainder for other purposes.

About four-fifths of all energy is consumed within the technically advanced nations and only about one-fifth within underdeveloped countries which happen to support more than two-thirds of world population. The United States accounts for 33 per cent of the total world energy consumption; the Soviet Union for 14 percent; Western Europe for 20 percent; and Eastern Europe for about 7 per cent.

We get energy from two broad sources: the animate (human and animal) and the inanimate. The common sources of inanimate energy - coal, petroleum, natural gas, and their associated materials - are all of mineral origin. So is nuclear energy. These sources of energy are irreplaceable, i.e., with use, they are used up. Recurring sources of energy—animate energy, wood, water, wind and direct solar energy—can be replaced or recycled. The modern technological world is being increasingly dependent on energy sources. So these recurring sources of energy will become much more important in the future than they are now.

It is interesting to know the history of man's discovery of the different sources of energy. The following table presents an historical outline of the discovery of these sources for different uses.

Most of world's energy production comes from inanimate sources: nearly one-half of it is derived from coal, one-third from petroleum, about one-sixth from natural gas, and about one-fiftieth from hydro-electricity. Most of the leading countries of Europe chiefly depend on coal. In Scandinavia and south central Europe, hydro-electric power is very important. Countries of eastern and southern Asia largely depend on coal. Petroleum is the sole source of energy in the Middle East, and it is very important in Caribbean America. The energy production is very much diversified in the United States and the Soviet Union. These two nations together produce over one-half of all energy.

Coal

As indicated earlier, about one-half of the world's total energy production is derived from coal. A century ago it supplied most of the world's inanimate energy. Coal, as you know, is made up of varying amounts of carbon, hydrogen, oxygen, nitrogen, and impurities. Depending on the heating value of its carbon, coal is divided into several categories from lignite through stages of bituminous coal to anthracite. Organic matter insufficiently decomposed and carbonized to qualify as coal is known as peat.

Coal is a sedimentary rock derived organically. Most geologists now subscribe to the theory that vegetation, once luxurient, was submerged in swamps and subsequently covered by other non-organic sediments. This happened in geologic history about 250 million years ago. The rate of replenishment of coal is so slow that it can definitely be regarded as an irreplaceable resource.

The Chronicle of Inanimate Energy

Source of inanimate energy	Approximate time of earliest specified use	Specified use
Wood	Prehistoric	Domestic cooking and space heating; perhaps handicrafts
Wood	Early historic	Handicrafts

(1)	(2)	(3)
Wind	Early historic	Transportation
Water	Perhaps early historic, certainly in classical antiquity	Handicrafts and crude mills
Coal	Early thirteenth century	Space heating and domestic cooking
Coal	Early eighteenth century	Steam engines for factories, coke for metal working
Coal	Early nineteenth century	Steam engines for transportation
Petroleum	Late nineteenth and early twentieth centuries	Space heating and lighting; domestic cooking; motors for transportation
Electricity	Late nineteenth and early twentieth centuries	Motors for factory machines and transportation*
Coal, Petroleum, Wood, Natural gas	Early twentieth century	Electricity generation in thermo-electric units
Water	Early twentieth century	Electricity generation
Electricity	Early twentieth century	Metal processing; space heating and lighting; domestic cooking
Natural gas	Early twentieth century	Space heating; domestic cooking
Nuclear energy	Middle twentieth century	Electric generation and specialized uses

*Experimentally

Table 12.2

World's coal reserves are primarily bituminus; they are extensive; and are unevenly distributed among nations. The total coal and lignite reserves have been estimated at 5 trillion tons. This reserve is sufficient to last for more than two thousand years at the current rate of extraction which is over 2½ billion metric tons per year. Over one-third of the coal and lignite reserves are situated in the United States, nearly one-fourth in the Soviet Union, and possibly as much as one-fifth in communist China. No other single nation is credited with more than 7 per cent of the world's reserves. Coal reserves of India are estimated at about 16.7 billion tons which forms 1.3 per cent of the world total.

Each year about 2½ billion tons of coal are extracted and consumed. Much of it isconsumed in the countries where it is produced. Only about 5 per cent of all mined coal enters international trade. Much of such commerce is concentrated around the north Atlantic. Western Europe accounts for three fourths of all imports and one-fourth of all exports. Soviet Union and eastern Europe ship about one-third of all exports and receive about one-fifth of all imports. One-third of all exports is supplied from the United States mostly to the countries of Western Europe, Canada and Japan.

The distribution of coal in the world is very uneven. Soviet Union is the largest producer of coal in the world. It has surpassed even United States partially because the U.S. has turned to other sources of fuel. These two countries together produce over one-third of total coal production. China, with about 10 percent of world production, ranks third. Other important coal producers are West Germany, United Kingdom, East Germany and Poland.

Of late, coal production is experiencing an unusual change. In the United States, Canada, much of Europe, the Soviet Union, Japan and some other technically advanced countries, the use of coal has been declining relatively in competition with petroleum products, natural gas, hydro-electricity, and other sources of energy. In other parts of the world, however, coal is in growing demand as a fuel. This is parti-

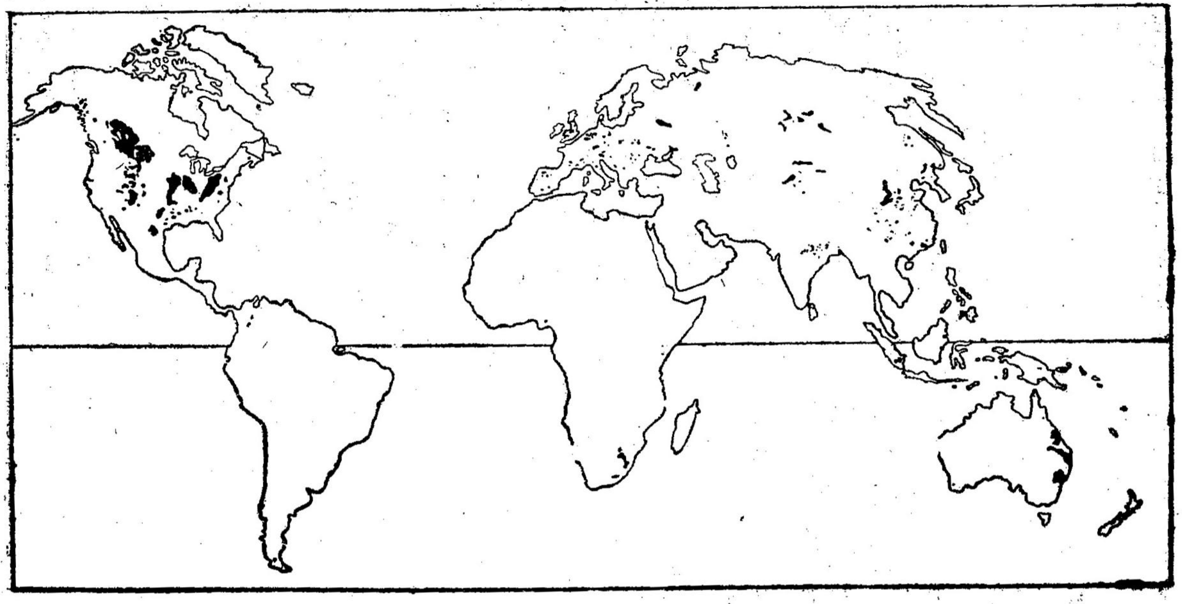

Fig. 12.1

Distribution of Coal Resources in the World

cularly true of developing economies as India and Communist China.

Petroleum and Natural Gas

Petroleum and natural gas rank next to coal in importance as sources of energy. They account for about one-third and one-sixth of the total energy consumed in the world respectively. They contain more energy per unit of weight as compared to coal and can be used also as raw materials in the chemical industry. They are efficient in energy yield and can be easily stored and moved. That is why the demand for these resources is rising so fast.

Petroleum and natural gas are composed of varying mixture of the elements, carbon and hydrogen, plus certain minor additional elements. They may occur in gaseous, liquid, or waxy solid form depending upon the carbon-hydrogen ratio. The term petroleum is applied usually to the liquid materials. Like coal, petroleum and natural gases have also been derived from organic sources and occur in complexes of sedimentary rocks.

The distribution of petroleum and natural gas is much more erratic than coal. United States and Soviet Union contain the most extensive sedimentary basins. Brazil, Canada, Communist China, Argentina and Australia have also interesting possibilities. The nations around the Persian Gulf in the Middle East aggregately control the largest known reserves in the world. Of other nations, United States and the Soviet Union are the leaders and Venezula is more than noteworthy. Unlike those of coal, known reserves of petroleum are sufficient to last for less than half a century at the current consumption rate and that has increased more than five times since the World War II.

One of the significant aspects of petroleum reserves is that about 75% of all known reserves occur in the underdeveloped nations. Middle East alone accounts for about 70 per cent. Caribbean America and, in lesser measure, the Far East are also important supply areas.

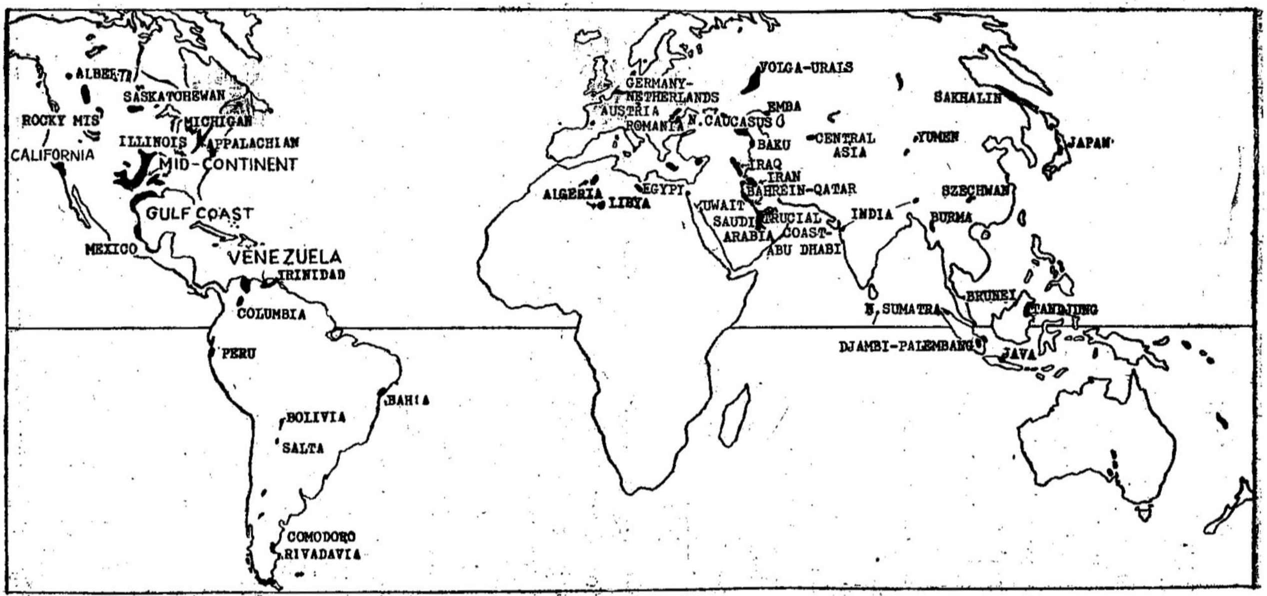

Fig. 12.2

Distribution of Petroleum Resources in the World.

The current production of petroleum in the world is around 12 billion barrels. U.S.A accounts for over 25 per cent of all output. Another one-fourth is produced in the Middle East countries, particularly Kuwait, Iran, Saudi Arabia and Iraq. Soviet Union is the second largest individual producing nation, followed by Venezuela. Other petroleum producing countries include Canada, Mexico, Indonesia, Rumania and Columbia. United States is the giant energy consumer accounting for more than one-third of all the world's energy consumption. It also consumes about one-third of the petroleum produced in the world. Other technically advanced countries in Western Europe consume about one-fourth and the Communist countries about one-fifth. Petroleum enters international trade in much bigger way as compared to coal. About 40 per cent of all crude produced in the world is exported. Circulation pattern is rather simple. Oil from Middle East and Caribbean area is shipped to Western Europe and Anglo-America.

Natural gas is another important energy resource. It accounts for about 17 per cent of all energy produced in the world. Only a few nations use it in sizeable quantities. United States produces about 70% of all natural gas and consumes a little more. There has been a phenomenal rise in the production and consumption of natural gas in the U.S. in the last three decades. Now it accounts for nearly 40 per cent of all energy consumed in the U.S., a figure exceeding even petroleum (35 per cent). Other countries which produce and consume natural gas are Soviet Union, Canada and Rumania. Proved reserves of natural gas are especially high in the United States (36 per cent of the world total), Soviet Union (12 per cent) and Canada (4 per cent).

Electricity and Nuclear Energy

Coal, petroleum and their associated natural materials have specific location in the environment and it is not surprising that man came to know them with the passing of time. Electricity and nuclear power are, however, more elusive. They have been realized more through man's reasoning

than through the use of his senses. Small wonder that they have come to be known so recently.

Electricity is more accurately, a form rather than a source of energy. Unlike fuels and nuclear sources, it is not taken directly from nature but is derived from man-made generators, Over 70 per cent of all electric energy comes from generators that are driven by turbines powered chiefly by (1) steam produced from coal, petroleum products, natural gas or atomic energy, or by (2) internal combustion engines powered by gasoline etc. Such energy is known as fueled-generated or thermo-electric energy. Nearly 30 per cent is obtained from generators driven by turbines powered by force of running water. This is called hydro-electric energy. A very small amount of electricity is secured from wind chargers, solar chargers etc.

About 7 per cent of the energy consumed each year comes from electricity, slightly more than 2 per cent from hydro-electric sources and the rest from thermal sources. Most of electric power production is concentrated in the developed countries. United States and Soviet Union lead the world in electric generation. Other important producers are U.K., West Germany and Canada. If most of the world's developed electricity is in the technically advanced lands, the potential—certainly for hydro-eletricity—is in the developing nations. The combination of rainy climates with land forms of atleast moderate height renders many underdeveloped countries potentially rich in this source of power. Africa alone accounts for 40 per cent of the world total potential, with Asia accounting for another 23 per cent.

Nuclear energy has gained great importance in the past few years. Though so far it has been developed only by the economically advanced nations, it has potentials for certain less developed countries that have lacked energy.

Water Resources

Importance of water to man has already been discussed under Hydrosphere. Water is perhaps the most important element of nature which man needs. It is essential for survival of human and plant life. Such precious element of nature is unfortunately most

available in required quantities all over the world. It's mal-distribution, scarcity and plenty, have always posed problems to man. Scarcity of water results in droughts and excess of water brings floods. These droughts and floods damage crops and create famine conditions. Such famines are quite common in India and other densely populated countries of the developing world.

The source of water supply is precipitation, particularly in the form of rainfall. We all know that distribution of rainfall over the earth surface is not uniform either in amount or seasonal availability. The tropical forests of the low latitudes receive very heavy downpours whereas the deserts get scanty rains. In India itself there are some areas where annual amount of rainfall is more than 1000 c.m. and there are some other areas where it is only 10 c.m. or even less. Similarly, in some parts of the world rainfall is received throughout the year whereas in some other areas it is received in a particular season. Greater part of India, for example, gets rainfall only in the summer months. Not only the amount of rainfall and its seasonal distribution is far from uniform, its availability is uncertain in many areas. This erratic behaviour of rainfall, its uncertainty of amount and time of receipt, are of paramount importance to crop farming and rainfall failures have often caused have and brought untold misery to man.

Man has learnt, over the millenia, to overcome the uncertainty of rainfall, to some extent, by providing irrigation to crops. Irrigation by constructing canals, tanks and wells, has helped to stabilize agricultural production in the world. In India, irrigation works provide water in times of need, to about one-third of the crop land. Tanks and reservoirs have been constructed to store water for irrigation. Dams have been provided on rivers to divert the water in irrigation channels. Man has made efforts to utilize not only surface water, he has also learnt the use of underground water. It is now possible to bring to surface the underground water from great depths. Irrigation tubewells operated by electric and diesel power have become popular in many parts of the world.

Though irrigation works now protect crops from the vagaries of rainfall in some parts of the world, there is great need to create such facilities in some other parts. As the population of the world is increasing every year, the demand for food, too, is increasing. It is therefore necessary to augment and stabilize food production. Provision of assured irrigation to crops and pasture lands will help the most in increasing food supply.

Along with maximum utilization of available supply of water, there is also great need to augment and conserve water resources. It is difficult to induce rainfall artificially and wherever it is possible, it may not be economical feasible. Still we can save substantial amount of water which is lost through evaporation and run off to sea. This can be done by increasing the vegetation cover of slopes and inducing re-charge of underground storage. Development of grasslands and afforestation on slopes will also help in checking soil erosion.

Biotic Resources

Biotic resorces include plant life, or flora, and animal life, or fauna. They constitute an important part of our natural environment and are of great importance to man. Human endeavours are greatly related to plant life. Grazing, fishing and hunting are vitally dependent on natural vegetation, though indirectly. The major occupation of man, agriculture, has developed out of man's domestication of wild plant life.

Land flora has often been classified in three groups: (1) forests, (2) grasses and (3) shrubs and tundra. Forests are generally found in humid climates, grasses in sub-humid climates and shrubs in dry areas. Tundra vegetation is characteristic of cold climates.

Forests, the most widespread of the three groups, extend discontinuously from latitude 70°N southward to the tips of all continents and major islands except Antarctica. Today, despite man's exploitation, they occupy about one-fourth of the earth's total land surface. The broad leaved forests of the tropical areas exceed the spread of the conifers of the cooler climates by

approximately a ratio of 2 : 1. Nearly one-half of the productive forests occur in relatively isolated areas, and inaccessibility puts a serious limitation to their exploitation. Slightly more than one-third of the forests are considered to be both productive and accessible and these are mostly located in the mid-latitudes.

Forests provide us with a large variety of products. The most common products are timber, fruits and nuts, vegetables, oils, natural rubber, turpentine, camphor, quinine and many other things. Many of these products are now domesticated and are obtained as part of agriculture. Among the commodities obtained from forests, round wood or raw timber is outstanding. Forest provide us about 2 billion cubic meters of raw timber annually. We use about onehalf of this production as fire-wood and the rest as industrial raw materials.

Of the different types of forests, the coniferous forests of the middle latitudes have been the best utilized. This is mainly because of the fact that these forests have soft-wood trees, and large stands of single species and climatic conditions are not as inhospitable as in the tropical forests. The low latitude tropical forests, on the other hand, have not been utilized as much because of the hard wood species, mixed stands of trees and very inhospitable climate. These forests have been well known for dangerous flies, insects and snakes and for malaria and other diseases. However, parts of these forests have now been cleared and plantations of rubber, sugarcane, coffee and tea have come up. Such plantations are particularly important in south-east Asia, West Indies and parts of Africa and South America.

Grasslands are equally useful to human beings. They support animal life which provide us with meat, dairy products, wool, hides and many other kinds of things. Majority of grasslands belong to either of the three categories of the savanna, the prairie and steppe grasses. The savannas are restricted to the low latitudes and fringe the low latitude forests of all continents except Asia where they are replaced by semi-deciduous trees, Prairies and steppes are found in middle latitudes. Prairies originally occupied extensive areas in Anglo - America and

Latin — America. The climates under which they thrive are excellent for a wide selection of crops, so they are being gradually obliterated. Steppe grasses usually fringe middle latitude deserts, providing a transition from them to the more luxuriant vegetation of forests.

Grasslands of the middle latitudes have particularly been important for rearing of cattle for food, wool and other purposes. The ranches of United States, Soviet Union, Australia and Argentina are well known for meat and dairy products. Dairing is particularly important in Denmark and north European countries.

Wild animals are more mobile than plants and their natural life zones are not so well defined. Moreover man has removed the wild fauna from the lands which he now occupies intensively. Wild life has either been pushed to areas which are inhabited by primitive societies or to sanctuaries where they form tourist attraction. Zoological water life is much more important to man and may become even vital as human populations increase. Of the more than forty thousand known categories of fish, over one thousand have been designated as commercial.

As a result of indiscriminate destruction of forests and the natural habitat of the wild animals, a large number of wild life species are slowly disappearing from the earth's surface. Of late, great concern has been witnessed all over the world to save these rare wild life species from total extinction. Wild life sanctuaries have been established in many parts of the world to provide natural habitat to the wild animals. In our own country a large number of national parks and wildlife sanctuaries, like the Corbett National Park, the Gir Forest Sanctuary, the Mudumalai Wild Life Sanctuary, have been established to protect and preserve wild life for the posterity.

Agricultural Resources

Agriculture, or production of crops on land, is the major occupation of man. More than half the labour force of the world is employed in agricultural pursuits. Agriculture

provides about 90 per cent of our food needs. It is also the major component of primary production. Grazing, forestry, fishing and hunting and mining also contribute to primary production and except mining, all these activities are closely associated with agriculture.

Crop plants are grown on land and they need warmth and moisture for growth. The technological level of the producer, man is equally important. All these factors of agricultural production, land and soil, climatic conditions, level of technological developments, and human needs greatly vary in different parts of the world. Accordingly, the form and composition of agricultural production also differs from place to place. It is possible to identify certain distinct types of agriculture in the wolrd. Primitive subsistence agriculture is practised in areas which have the lowest level of technological development. Such areas lie in the tropical rain forests and sub-tropical forests and grasslands in the low latitudes. This type of agriculture is characterized by the use of crude techniques and rudimentary implements to produce food for the family and the kinship group. In more developed areas primitive subsistence agriculture gives place to intensive subsistence agriculture. It is the most widespread type of agriculture and is practised over about one-third of the crop land of the world. It is characteristic of the densely populated areas of south and east Asia, particularly countries like India, Pakistan, China, Japan, Indonesia and Burma. Because of high density of population and large food needs, the intensity of cropping in these areas is heavy. Usually more than one crop is taken from the same piece of land in a year. Still the level of technology is low and yield of crops per unit area remains poor.

Plantation agriculture is characteristic of low latitudes where individuals and corporations manage large plantations of rubber sugarcane, bananas, tea, coffee and many other crops on commercial lines. Commercial grain farming is found in sub-humid climates in the middle latitudes of North America, Central Asia and also in Latin America and Australia. It involves the use of machines, much land and few people. Wheat is the outstanding

crop, followed by other small grains like barley and oats. Commercial crops and livestock farming is practised in middle latitudes in technically advanced countries of the world, particularly in North America and Eurasia. This system of farming is based on scientific crop rotation which alternates soil-depleting and soil-building crops in successive years. The corn belt of the United States is an example of this type of farming. Commercial dairy farming is popular in areas where climatic conditions, particularly short growing period, put serious limitations to grain farming. Short duration grasses can, however, be grown and dairy and other animal products can be obtained for the use of the urban-industrial centres. In the vicinity of the metropolitan centres people tend to grow vegetables and fruits.

It is thus seen that man has learnt over the years to make use of his environment and produced crops or raised animals to meet his food and other requirements. Depending on the level of technological developments of people, the use of euvironment may be more efficient or less efficient. In less developed areas people grow mainly food crops to feed their family. In areas where technological development is high use of environment is more efficient and high yields of crops are obtained. Agriculture is also diversified in these areas to meet the large range of human needs. Technological developments have made it possible to bring exotic plants from other environments, and also cross-breed the crop varieties. The high yielding varieties of crops, inorganic fertilizers and plant protection measures, and improved methods of crop husbandry have revolutionized agriculture in many parts of the world.

Agriculture not only provides us with food but it also makes available a large variety of raw materials for industrial processing. Thus, cotton provides raw material for manufacture of cloth which is so necessary for human beings. Sugarcane, tobacco, oilseeds and jute are some other crops which provide raw materials for industries.

Fisheries

Fishing and hunting are very old occupations of man. Today they do not provide a livelihood for large number

of people. Hunting, as a means of livelihood, is now limited to some primitive societies only. Fishing continues to be a commerical occupation and about 1 per cent of the world's labour force is engaged in these activities. Measured in terms of employment, fishing is about equal in importance to forest-products industries and to grazing, and about one-half as important as mining.

The total fish catch of the world is about 50 million metric tons annually. Of this some 25 million tons are actually consumed by human beings and about 16 million tons are made into animal and poultry feed, fertilizers, bait, etc. The rest is utilized for some other by-products or discarded.

Maritime fishing is important on the coasts of south and east Asia, on Peru and associated Pacefic coasts of South America. Pacefic coasts of United States, Canada and Japan, and the North Atlantic Coasts of western Europe and eastern U.S.A. and Canada. The famous fishing grounds of the world include the Japan coast, the Grand Bank of New-foundland, the North Sea coast, and the Peru coast. Fresh water catches are taken mostly in southern and eastern Asia from shallow ponds, rivers, inlets and fields.

Consumption of fish as food is particularly important in the densely populated areas. More than one-third of the world's fish catch is consumed in Asia and about one-fifth in Europe, one-tenth in the Soviet Union, and almost as much in the United States and Canada. In the Southern hemisphere, Peru is the most important fish consuming country.

Technological advances in recent times offer new possi-bilities in commercial fishing. Fishing technology has vastly improved and catches can be had from a much larger area now than in the past. Techniques of acqua-culture have made it possible to propogate and produce desired species of fiishes at the desired periods in shallow coastal seas. Inland fishery has gained great popularity in the recent past in densly populated areas of the world. No wonder fish products may assume greater significance in future and sustain much larger human population than they do today.

EXERCISE — 12

Short answer questions

1. Define the concept of resources.
2. Classify the natural resources.
3. How are soil resources vital for human life ?
4. Give the various types of energy resources.
5. Mention few areas where we have abundant coal resources.
6. Give a few names of the areas where we have abundant petroleum resources ?
7. What do you mean by nuclear energy ?

Essay Questions

1. Analyse the growth of population in relation to the utilization of natural resources.
2. Write an essay on the world distribution of energy resources.
3. Bring out the importance of water resources in the study of environment.
4. Discuss the various aspects of agricultural resources.

13. Human Resources

Man is a part and parcel of the Biosphere. Man came into existance about one or two million years ago. His evolution was due to the changes in the physical environment. He spread to the different parts of the world and adapted his modes of life to varying environments. Human activities utilised the natural resources and provided the basis for economic development. The impact of man on the environment depended on the type of natural environment, man's levels of culture, his technological know how and his basic needs.

Prior to the Industrial Revolution when agriculture was man's main activity in nearly all parts of the world the population distribution in each country tended in course of time to become more or less adjusted to variations in the quality of the land. The typical result was an uneven distribution, population was heavily concentrated on land that could produce large returns with minimum effort and equipment. With the advent of the Industrial revolution that took place in the west in the 18th century, importance of natural resources as a factor of population distribution has become evident. In comparison with the distribution which subsequently evolved in the countries that become highly industrialised, the pre-industrial distribution of population was one of relatively uniform density over wide areas. Industrialisation and mechanisation of the world economy have increased the importance of natural resources as a factor of in fluencing the distribution of population. The present distribution of Industry and trade in such countries as the United States, U.S.S.R., U.K., France, Germany Australia and Poland reveals the prime importance, at present of the availability of fuel and mineral resources and technological advancement as a base for industrialisation.

Distribution of Population

The distribution of population over the surface of the earth has been very uneven throughout the history of man. In its broadest aspect, the earth may be divided in the first instance

into inhabited and uninhabited parts. The ability of man to occupy different environments and push out the boundaries of inhabited regions, increased with advance in Civilisation; development of clothing and fire made possible the occupation of colder lands; Taming wild horses and camels opened up the arid and semi-arid lands and when man was capable of navigating the oceans, the space available for occupation substantially increased and the horizons of his habitable land, much widened. The search was always for new living space driven by the urge to discover valuable economic minerals. The last few centuries have witnessed a spread of European agricultural settlement within the habitable world.

The spread of man has been aided by the discovery and utilisation of minerals, on an enormous scale, the sub—stitution of power driven machinery for human and animal labour, the spread of old world grains into the grass land of the middle latitudes and the diffusion of old world crops such as sugarcane, coffee, rice, plantain and the new world crops such as potatoes, manioc, maize, tobacco and upland cotton and the extension of irrigation and drainage by modern methods.

The spread of popu'ation and the extension of the habitable lands at the expense of the uninhabitable lands has led to the humanisation of larger areas of the: world. This has necessarily meant that man has been able to modify the natural environment into a cultural or man-made environment depending on his needs, the natural resources and his advancement in science and technology. Considering the total expansion of population and the search for new settlement areas, it appears as though the remaining unoccupied lands are those which present serious obstacles for settlement at the present level of technological development. These obstacles are primarily climatic in character, for it is the cold lands, (polar ice caps) the dry lands the hot deserts and the humid tropical lands (equational-regions) which comprise most of the uninhabited or sparsely populated lands of today.

90% of the total world population live in the Northern Hemisphere among which, Asia alone accounts for nearly 57%

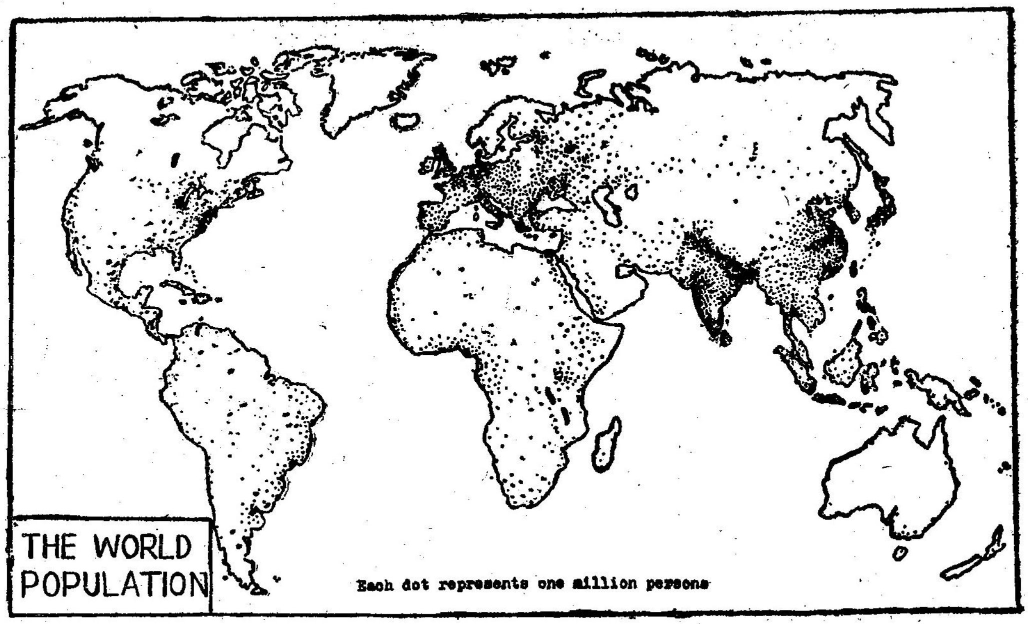

Fig. 13.1

World Distribution of Population

of the world population, Europe including (USSR) 19%, Africa 9.5%, South America. 7.8%, North America 6.3%, and Oceania 0.5%.

World Distribution of Population

The pattern of distribution shows wide variations within each continent. Some countries with large populations are: China (750 million), India (550 million), the Soviet Union (250 million,) U.S.A. (210 million), Japan (105 million) and Indonesia (100 million). The distribution of population can also be studied with reference to population per square kilometer of land. The average density of population for the world as a whole is 27 per square kilometer. But the actual density varies from region to region, the range being less than 10 persons per square kilometer to over 1000 per square kilometer. Sharp boundaries separate areas of high density from areas of low density, and this disparity in density is quite striking not only on a world basis, but also within the different countries themselves.

High Density Regions

4/5th of the world population are concentrated in three Clusters of subcontinental size:

1. The major regions of high densities are the two Asian cluster — (a) East Asian cluster comprising of China, Japan and Korea and (b) the South Asian cluster comprising of India, Bangladesh, Sri Lanka and Pakistan. These two clusters alone account for more than half the world population.

2. The second region is the North West European cluster which includes Great Britain, France, Belgium, Netherlands, Denmark and West Germany. There is a continuous belt of high density oriented East to West along the 50th parallel of latitude from theNorth Sea to the English Channel upto the lower Dreper basin in the Soviet Union. This is called the European population axis and is concident with the highly industrialised urbanised regions of Europe. This cluster accounts for nearly a fourth of the world population.

3. The North Eastern parts of the United States accounts for less than a fifth of the world population.

The European and North American clusters are in the middle latitudes whereas the two Asian clusters are Tropical and Sub-tropical in their location.

Moderate Density Regions

Moderate density regions are the Central and Southern Europe, European Russia River Valleys of South East Asia, Coastal Plains of the middle latitude regions of South America and South Africa.

Low Density Regions

The low density regions cover vast areas of the equatorial regions, tropical deserts and mountain tracts, with a density of less than 5 persons per sq. km. Polar regions have extremely low densities.

Summing up we can say that physical factors like high relief and unfavourable climate to a very great extent, limit population distribution. Cultural factors like modes of life also affect population density. Primitive economies like food gathering, hunting and fishing and shifting cultivation have low densities of population. The areas of subsistance agriculture like the alluvial plains, river valleys and deltas support a high density of population. The growth of industries and urban centres also support a high density of population.

Growth of Population

The fundamental problem that faces the earth today is the rapidly increasing pressure of population on the resources of the land. The earth's land surface is inextensible while the population continues to increase. The table below indicates the rapid in population in recent years with that of man's earlier history.

Growth of World Population

Millions	Year (approximately)	Years taken to increase world's population by 1000 million
1000	1830	300,000
2000	1930	100
3000	1960	30
4000	1975	15

Calculations based on the present rate of increase suggest that within 260 years there could be 400,000 million people.

The total world land area is 148.8 million sq. kms and the population is 4000 million as estimated in 1976. Of the total land area 1/5 is too rugged and too high, 1/5 is too cold and 1/5 is too arid and 1 10 is composed of bare rock out-crops and hence unsuitable for agriculture. Therefore the total land area available for human settlement is only 30% ie. 44.64 million sq. kms.

Composition of Population

The distribution of population in terms of numbers of pepole living in different regions gives only one aspect of the picture. The needs and aspirations of the people vary widely depending on cultural, social and other factors. For example, though the United States has a population less than that of India, it consumes more energy. Even in our own country, there is striking contrast between urban and rural population, While the needs of the rural population are limited, urban centres get their requirements from a large area. There is an increasing tendency towards greater urbanisation all over the world.

Besides the contrast between urban and rural population, there are other differences such as those relating to occupa-

tions, religions, languages and standard of living. If we consider occupational pattern, the number engaged in primary occupations such as agriculture is declined rapidly in the developed nations of the world. More and more people are engaged in secondary and tertiary occupations. In the developing nations, a high percentage of population still depends on primary occupation such as agriculture for their livelihood. Secondary occupations such as manufacturing industries and tertiary occupations such as trade and professional services have not developed to a great extent.

The diversity in religions is reflected in the cultural landscape in the form of temples, churches. mosques, etc. Religious beliefs may have an impact on the economy. Religion may provide a link or form a barrier between nations. The diversity in levels of economic development is of much greater concern from the point of its impact on the environment. The developed nations are consuming the non-renewable resources at a much a higher rate per capita that these resources are likely to get exhausted in the near future. The developing nations, on the other hand, are unable to compete with the developed nations in getting the resources needed by them. Thus it becomes evident that the composition of population has a much greater significance to the total number of people living in an area.

Future

The rapid increase in population in the last fifty years has raised serious doubt about the future of man on the earth. Will there be adequate food for all the people in the future? Will there be adequate energy to serve the needs of the people? Will there be enough land not only for cultivation but also for settlement and other agricultural needs?

There have been both optimistic and pessimistic answers to these questions. It may be said that man will evolve new technology to tap new resources to provide food, power and other needs. The optimists consider that the earth is capable of supporting a much larger population. On the other hand, the pessimists feel that the carrying capacity of the earth is

limited and there will be severe shortages of food, power and other resources. People will die of starvation or lack of the basic necessities. There is need for checking the growth of population and at the same time reducing the rate of utilisation of resources.

Population Capacity of the Earth

The carrying capacity of the land varies from one region to the other depending on the richness of the land and the cultural landscape. The monsoon lands of the world support more people than the steppe lands. Similarly industrial regions support more people than the agricultural regions, mainly because of the higher returns from such areas.

Economic, Social and Political Implications of Population on the Environment

Wherever there are human beings there is economic activity of one type or the other. Human society rests upon man's ability to produce economic goods. Economic production is a process wherein man takes what he wants from the natural environment to obtain the means of life. He capitalises on and develops special elements or combinations of elements in the natural environment. For example man utilises the element soil, his economic adjustment may be termed 'agricultural'. Soil therefore can be regarded as a basis of agricultural development. Relief, climate, drainage etc. may be potent secondary factors which help to determine the specific nature of man's adjustment to his surroundings; similarly regions which are rich in minerals becomes mining regions provided the depth at which they occur the thickness of the deposits etc. make exploitation of minerals feasable and economical.

Besides economic adjustments (individually and collectively) man makes with which the natural environment there are diverse forms of social adjustments. Society everywhere lends to adjust its form and structure through a process of selection and development so as to fit harmoniously with its surroundings. This arises due to the tendency of human beings to work out social arrangement to satisfy their gregariousness. Also the fact that

any particular economic adjustment on the part of the society calls for certain social arrangements, structure and habits in order to function efficiently. For example many forms of pastrol adjustments call for nomadism or at least semi-nomadic social habits, agricultural development call for rural living whereas commercial and manufactural adjustments usually give rise to urban groupings. The agricultural developments completely change the landscape in that they necessitate the clearing of forests and covering the area with fields, harnessing the surface and sub-surface water resources for irrigation. On the margins of these cultivated patches are found the houses of landlords and agricultural labourers. Similarly mining settlements give rise to a completely different landscape than that found before the exploitation of minerals. These mining operations lead to the development of small towns; Jharia, Raniganj, Durgapur, Danbad are good examples of how towns have grown due to the mining operations. Commercial and manufactural establishments likewise give rise to the development of very good transportation and communication systems, lay out of buildings for factories, worker's houses, shops and places of eating.

The numerous economic, and social processes going on within a society make necessary a considerable amount of political adjustments in governing, regulating and laying policies for the society.

The Political traits of mankind are to a large measure ecologically determined, example, the control of raw materials, safeguarding of the investments, domination of lines of access, the control of strategic and commercial locations, protecting water rights etc. All are instrumental in creating political adjustments which will to a certain extent harmonise the economic life of people. The social economic adjustments bring about certain group attitudes and create problems of social control. There is need for suitable political structures and institutions. There is a need for the part of any social group to maintain effective control of the area of land which it claims as its own, which leads that social group to make direct political adjustments to the natural environment. These include the internal political organisation which will sustain

that control; delimiting satisfactory boundary of the area and maintaining effective relationship with other groups occupying neighbouring areas.

Human society is thus compelled to adjust itself to the area which it inhabits.

EXERCISE — 13

Short answer questions

1. Which are the uninhabited regions of the earth ?
2. What were the factors which help in pushing the boundaries of the inhabited regions ?
3. Mention the largest countries of the world from the point of view of the population.
4. What are the implications of the economic development on the environment ? Give example.
5. What do you mean by the term 'carrying capacity' of the land ?

Essay questions

1. How do the cultural landscapes of any region vary according to the composition of the population in a region?
2. Give an account of the distribution of population on the surface of the earth from the early times.
3. With suitable examples explain how and why population density varies from region to region.

14. Environment and Information Base

We have seen how diverse components are associated with the study of the environment. When we study a river, we have seen how the river-flow varies from place to place, how it gets its water, how the river water is used etc. , When a dry river bed is seen, then, the prospects of getting underground water is discussed. Then we have see how rivers influence agriculture and human life. Therefore whatever may be the element of the environment that we have to seen, it involves a chain of the understanding of other elements of the environment. This enables us to know that the information on environment is vast , varied and inexhaustive. When we gather various information of the environment, then our understanding of the environment will be of in depth and practical use.

Information gathering is one of the very important steps in the understanding of the environment; gathering and providing it for practical purposes is of greater value. Our understanding has shown that various complicated aspects are involved in information gathering. Therefore relevant information on environment is intermingled with irrelevant one which is unwanted. Gathering relevant information needs pre-planning and precision measuring techniques in information collection. Once we collect relevant information, then based on that we can plan our living on the earth more happily. For example when we know about the amount of rainfall, surface water-flow, availability of underground water, and the amount of water required for various purposes like agriculture, domestic purposes, and industry etc. , then we are able to state how much water can be diverted from each sources for different uses. Therefore collection of environmental information is very valuable and is for the

purpose of better understanding, better planning and better utilization of the environment.

How Is Information Created?

What we can see and what we can count are information. By seeing we identify the differences in terms of sizes, colour, character, behaviour, etc. When we observe a hill and a rock, we differentiate one from the other by means of their comparative sizes. In the sameway lakes and oceans are differentiated, streets and highways are differentiated. Colour makes the difference between soil groups, human groups (races) and, even depths of the water will be differentiated. It is customary to say 'he is a good person' based on one's own character. The hardness as a character is identified from different rocks, and different metals, etc.

On the basis of our observation of the various elements of components and differentiating them one from the other, we are able to get environmental information.

Therefore the basis for environmental information creation (gathering) is making observations and differentiations of various aspects of the environment. When we observe a person we say he is 'good'; rains in a day, we say 'raining'; and elevated land mass, we say a 'hill' etc. By making these verbal statements, we differentiate one aspect from the surrounding aspects and by which we observe that part of the environment. This is called qualitative measurement of the environment.

However there is a shortfall in the qualitative statements. When we say, "this is a high mountain" we do not know how high the mountain is. The high may be as high as 500 metres or 8000 metres. But when we express it in terms of height either in meters or feet then it is understandable by every one.

Therefore numerical values take the role of eyes where eyes fail to differentiate the things very precisely. By numerical assessment we are able to measure precisely and it will be given in what is called quantitative forms. Quantitative measurements are made through various devices. The devices are

many and varied. To measure the climatic elements such as temperature, pressure, winds and rainfall we know that there are numerous devices. These devices range from simpler thermometers to complicated sensors installed in weather satellites.

Types of Information

Many types of quantitative and qualitative informations are available. Our study of the natural environment includes landform, biotic and atmospheric aspects. Therefore there are landform information, biotic information and atmospheric information. To measure these aspects, many instruments are available. Different land survey methods give us length, breadth, area, height and volume information of the physical environment. Physical and chemical analyses give us precise information on composition and structure individual elements.

Man builds large towns and factories, automobiles and such other things which are all again the various information. Man's food habits and traditions bring different types of agriculture, house types, art and architecture. These are all the results of human advancement in resource utilization. Man himself varies from place to place in terms of his density. The information resulting from Man's number and his impact on resource utilization is enumerated in records and are maintained. Collectively these are called economic population and cultural information. Measuring the cultural information involves the habits, traditions and attitudes and reactions of the human society.

However these various kinds of information are, in a modern way, described as proximal, and non - proximal information. The proximal information can be gathered when we go to the object directly and gather the details about it. When the surveying of land use is involved we can go to the spot and we can measure the various landuse types; in the same way population of villages and towns can be counted, number and types of trees in a smaller forest land can be enumerated and peoples, reaction over the sugar factories on waste disposal can be measured.

However, when we cannot get into the details, we adopt some other methods to extract information. Suppose remote

places like Ladak Valleys are to be mapped or we want to know the exact area destroyed by the chemicals of a chemical factory, then indirect ways of gathering information is adopted. We fly an air - plane with camera and photograph the Ladak region. This is called non - proximal information.

The proximal information is gathered through various ground survey techniques, whereas non - proximal information collection is done through remote - sensing techniques. The modern scientifc and technological development have reached a stage in which even the proximal information can be gathered in a non - proximal way. The settlement (where people live) forest, wealth, wild animals, landuses, and different resources can be located with the help of the remote - sensing techniques.

Sources of Information

Statisticians have established that information can be gathered from primary surveys or from secondary sources. The secondary sources are existing published or unpublished records. These records are maintained by government agencies, trade associations, research bureaus, magazine, news papers, etc. Sometime these records are freely available in the form of sensus publications and various statistical reports. Some of them are restricted and cannot be used without getting necessary prior permission. These are normally preserved records for some national value or national security. Our archieves store historical data for national value. Data on defence production, power installations and such other details are restricted for security reasons.

Other important secondary informations are in the form of photographs and maps. These are all special documents. The preparation of these documents involves very careful planning and lot of technical skill. To understand the information from those one's interpretative capacity is an important prerequisite. However, now there are photographic scanner, which will call the information and produce it in easy understandable maps. Then black and white photos are called imageries. The X-ray of a person is one such imagery. The

other well known imagery is TV images. There are microwave images, sounding images and radio—images.

Where we cannot meet the requirements from the secondary sources we may go for the collection of first hand information. This has to be well planned and executed with maximum care. The primary collection of information is made through the field methods. Field methods include the use of various tools and techniques in data collection. Land-use surveys, soil surveys water pollution assessment etc, are recorded by measuring through the observation techniques or by making use of the instruments in recording the data.

When we are interested to understand the impact of carbon or nitrogen or the impact of chemical effluents, observation is made on a smaller area. If it is necessary, it is also assessed through the use of different instruments by different tests. Properties of water, atmospheric moisture, soil fertility, diseases in plants and human bodies are assessed in this way. Based on his environmental informations are recorded.

The other way of recording primary information is through simple observation of counting. Mineral production, fish catch on a particular day, number of automobiles passing through an artery of transportation are recorded in this way.

However the attitude and response of the human communities cannot be completely assessed through the observations which we have discussed. Survey techniques can be used to extract the information. The survey techniques are of two kinds. They are interview techniques and questionnaire techniques. In the survey techniques the questionnaire and interview are comparable to the different instrument used for testing of soil, chemicals etc. Therefore these are called tools of survey techniques. The use of questionnaire as tool is comparatively restricted. Questionnaire contains a number of questions for information which we seek. This questionnaire will be given to the individuals or individual organisations and they themselves

provide the information which we seek; whereas in interview we will put questions and the responses of the individual or individual organisations will be recorded. So to gather information through the questionnaire the community should be able to go through the questionnaire by themselves; whereas in interviews this is not pre-requisite.

In collecting information from documentary sources or by primary surveys, we have limitations. For instance it is proposed to know the hardness of sea water along the Tamilnadu coast. Theoretically it varies in every centimetre area of the sea surface. Apart from this it varies between day and night and between seasons. In that case, making an exact measurement of the hardness of the sea water is beyond our scope. In that case, we have to be satisfied with acceptable accuracy of the information. May be a few spots will be located with equal intervals, say for every 10 km. of stretch along the coast and from each spot some 50 ml. of sea water is tested and bassed on that, information is recorded. Suppose we are interested to understand the village communitie's adjustment to the natural environment, we can study two or three villages and based on that we can record the required information. Basically this method of recording information by studying a few is called sample surveys. The sample survey follows certain statistical rules. Sample surveying is classified as random sampling, stratified sampling, systematic sampling and cluster sampling. In enviromental information gathering however the aerial distributions makes the matter more complicated; we have to decide whether we are going to select samples as small spots (points) or along a line (transit) or a smaller enclave (quadrat). This problem is successfully solved by what is called aerial sampling.

However, we may not be in a position to record information by the statistical sampling procedures Because the very important pre-requisite for the statistical sampling procedure is that we should have basic knowledge about the

details under study. In the circumstances in which we do not have basic knowledge we have to gather information by purposive sampling. For instance when we are interested to understand a tribal community and its environment then we would choose purposive sampling. In the sameway the information on wild animals and plants will be based on purposive sampling. But for some other purposes, there is no alternative than to gather information about the 'all' (not a few). Based on how many villages are located in a part of a state we cannot conclude that so many villages are there in the state. For this purpose we have to count all existing villages only then we can make the statement. It is called as absolute census.

Information from Ground Survey

Recording information from proximal sources is normally achieved by ground survey techniques. The ground survey techniques are of many types to suit the needs of the varied purposes of information gathering. It can be noted that the environment has stationary (physiographical features, roads etc) and mobile (air, transports, attitude of the people etc.) aspects.

Information from stationary things is recorded through various types of geodetic and plane surveying. When a large area is involved in surveying then it is one of the geodetic surveying. On the contrary a village and its environment is prepared in a plan with all ground details, there it is a case of plane surveying. Apart from this depending upon information that we seek, these surveys vary from geographical surveys, to geological surveys, forest surveys, soil surveys, archaeological surveys etc. The instruments used in these surveys range from simple metallic tapes, compass and theodolites. The principles used in these surveys are very simple. The distance between objects pre-recorded by making use of any one of the distance, angular and height differences or combination of them.

Mobile things are recorded by enumerating them. Population enumeration conducted once in ten years in India gives information on human population. Number of automobiles manufactured and registered as road worthy are enumeratep and recorded. On the same lines sociological, economical and cultural details are recorded. These are collectively called statistical surveying. As referred earlier, statistical surveys are by recording all census or recording a few (sample surveys-) However, the statistical surveys vary from one another as population surveys, sociological surveys, economic surveys, industrial surveys, agricultural surveys, etc. depending upon the purpose involved in it.

Yet another kind of recording information from environment is one of the difficult tasks as in the case measuring atmospheric air-structure. Various thermometers, barometers and anemometers are used for this purpose. Measuring attitude of the people towards political parties, natural hazards and marketing and shopping is of complicated one. There is no precision measuring device available to measure and record this kind of information. The measurement of this type is normally called as qualitative measurement. :Recording of qualitative information is collectively called opinion surveys and attitude measurements. Depending upon the details which we seek, and the skill of the persons conducting: opinion surveys, information gathering will vary.

Information from Aerial Survey

When we are interested to know about the submarine topographic features of Bay of Bengal we cannot go deep carrying all our ground survey equipments and record the information. In circumstances like these, some methods — called Remote sensing or non-proximal methods—are adopted together and record environmental information. Remote sensing methods are not only for those details to which with our conventional requirements we cannot reach but also for details which cannot be otherwise detected. We know that when sunlight falls over different objects the impact will be different. Sun's energy contains heat and light energy. Light energy is reflected or

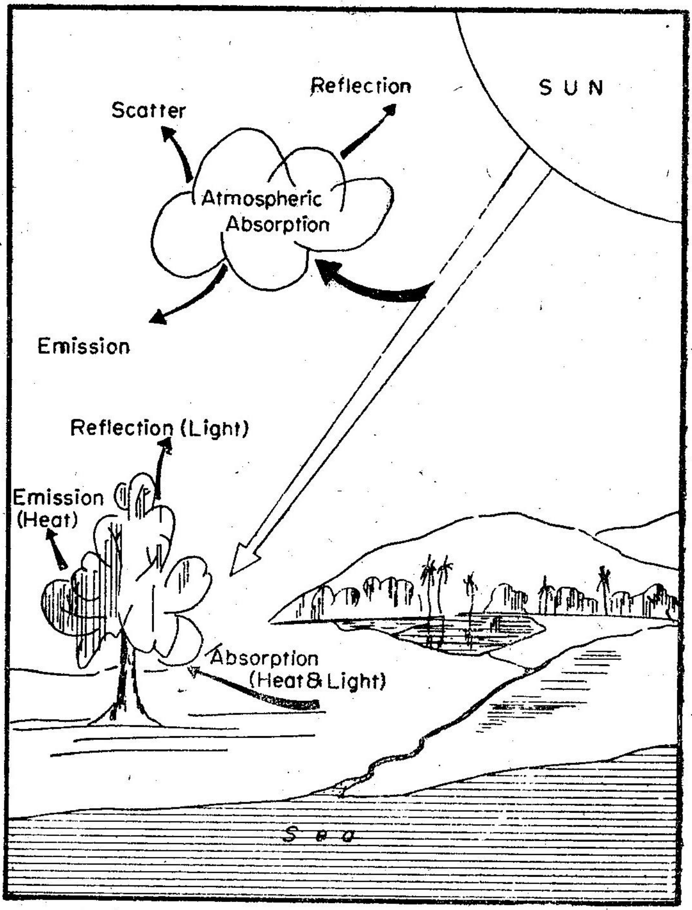

Fig. 14.1

Sun and the Sources of Remote Sensing Imformation

refracted or scattered when it falls over the elements of the environment. In the Same way heat energy is absorbed and the nit is radiated. But the amount and the rate of returning light and heat energy of different bodies vary. We know very well that land absorbs and radiates sun's heat at a faster rate than the ocean. When we walk very near to the organic decay they are warmer because the decayed organic matter radiates more heat than the living organic ones. If we are able to record this information this will be a great use for agricultural disease control and water pollution control.

Apart from this we knew very well that through telegraph and radio, information can be transmitted from place to place. Vibrations of sound and light are sent through these methods. Suppose we send vibrations to various objects they will come back as reflections. When we shout in a very big hall we get echo and this is an example of how sound vibration will come back as informations. Remote sensing is able to record vibrations and produce records of information.

Sun energy is described as the electro-magentic spectrum. Remote sensing techniques vary depending upon which part of the electro-magnetic spectrum of the sun's rays is involved in recording the information. What human eye is able to see is only a smaller part of the electro-magnetic spectrum and is called visible part of the spectrum. When light and heat travel in the form of waves, then vibrations are also created. Therefore apart from light and heat sun is able to produce vibrations.

Gamma rays, X-rays, Ultra - violet rays and in certain extent Infra-red rays radiate more heat energy than the other parts of the sun's energy. The micro-wave, radio and TV waves are associated with vibrations of the sound rays. In a photograph we can see aspects of light energy very clearly. Even the green, red and other colours are recorded in different tones of black and white with which we are able to differentiate the objects one from the other. Apart from this, colour is also another traceable property of light. In short, the

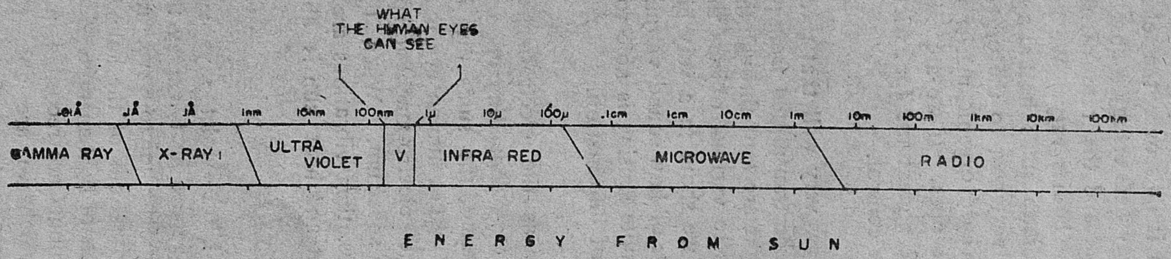

Fig. 14,2

Different forms of Remote Sensing Information

Fig. 14.3 **Aerial Photograph**

various qualities of light and heat energies are used to record details of the environment through remote sensing way.

Remote sensing of the environment is basically aerial surveying. We fly over the object, and when we are in the 'air' we make the 'survey'; so it is aerial surveying. Aerial surveying is done from aeroplanes, satellites, rador stations and even from tall structures (either from mountain or hill top or from a light house). When real objects are recorded through lenses it is called photograph. Otherwise if only images are recorded through electro-mechanial methods it is called imageries (eg. X-rays, TV images). The simplest record of the remote sensing is the photograph taken from the aeroplanes. They are called aerial photographs. Aerial photographs are either in black and white (panchromatic) or in colour. Aerial photographs are obtained by aerial cameras which are fully automatic.

When we record radiation, brightness of light and vibrations of the electro-magnetic energy, then sensors are used. The sensors are otherwise called scanners. The scanners act like cameras and are capable of producing imageries. Radiation sensors are radiometers, spectrometers, and polarimeters. Light scanners are collectively called optical - mechanical scanners. The vibration sensors are used in the radio stations and airports. In round techniques ultrasonic sounds in the form of micro-wave vibrations are sent and reflections from the objects are recorded by which information is produced. These instruments are common oceanographic surveys.

Information gathering by remote sensing techniques have more advantages than the group surveys. By remote sensing, flying in a aeroplane, we are able to record information from a larger area. Secondly it saves lot of persons involved and time involved which are common in ground survey methods. Thirdly, as already we have seen, even inaccessible areas are covered; otherwise we will not be able to know for example the various planets in our Universe. Yet another important result of remote sensing is that there are certain other information the recording of which is otherwise not possible. Now modern

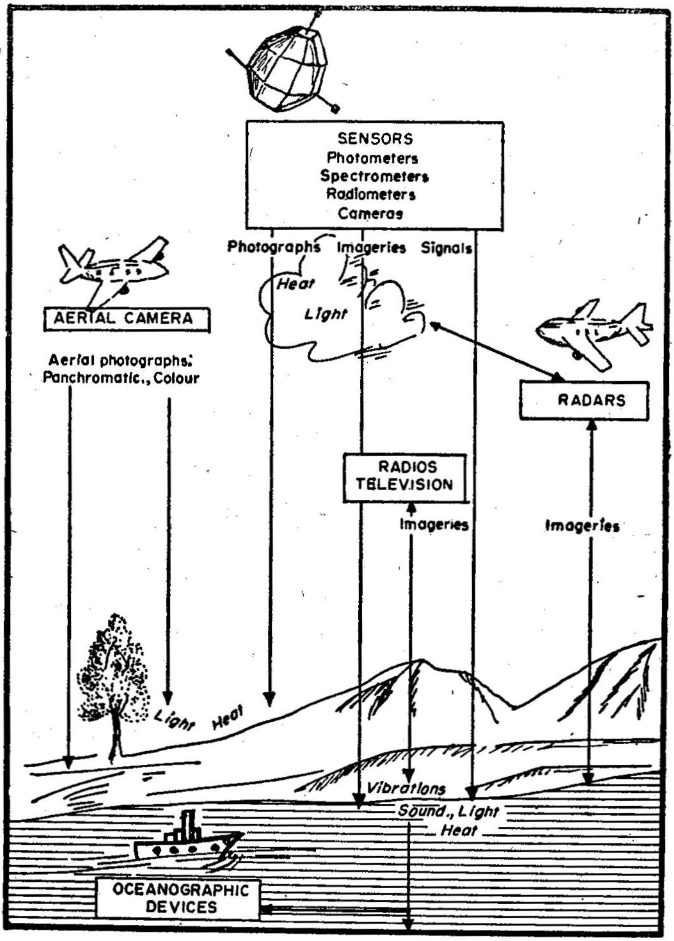

Fig. 14.4

Remote Sensioa Equipments and Information records — Simplified Chart

satellites with all remote sensing equipments fly over the earth and are able to produce information records.

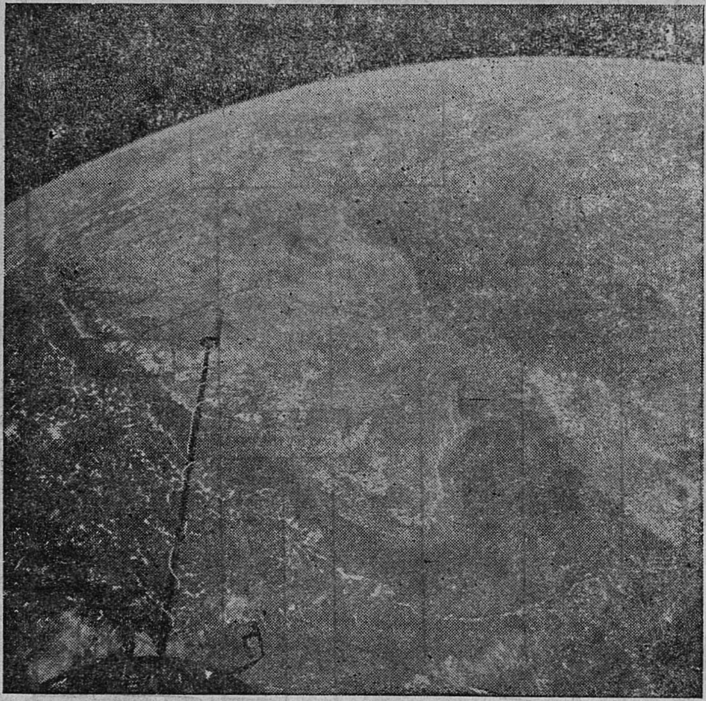

Fig. 14.5

Information by Satellite

Weather Information

Long before the advent of science, men watched the sky and observed the heavenly bodies and estimated the different seasons and changing weather. They were able to choose different seasons for different purposes. Even today as we know, the general merchants put more number of umbrellas and rain-coats in the show-case during the rainy season. Irrigation development, aviation and tourist developments are directly

associated with how precisely we estimate the weather elements. Diverse natural vegetations, agricultural patterns and house and dress patterns tell us how weather and climate influence the human living. Therefore weather information is one of the very important aspects and has more practical value.

Modern weather information is collected by more sophisticated instruments. These instruments measure temperature pressure, humidity, wind, clouds and precipitation conditions of the atmosphere.

Weather informations are collected at stations widely distributed and are recorded periodically. Based on the information, they tell us, when rain is likely to occur; or when we can make a safe air-travel etc. These stations are called Meteorological Stations. Periodically they publish weather information in the form of weather charts and weather maps. For example, the Indian Meteorological Department which controls all weather stations in India publish 'Indian Daily Weather Reports'- These reports contain weather details of the different stations distributed all over India. Weather maps generally, are based on pressure conditions. Because pressure makes wind movements and that is the cause for major weather changes. In weather maps, therefore we can see isobaric conditions.

Meteorological Stations

The meteorological stations are marked as circles in a weather map. These stations record weather information twice in a day; once at 8-30 hours in the morning and another at 5-30 (17-30) hours in the evening. To know the weather information over the sea-surface, the ships sailing in different parts serve as weather stations. These ships record sea conditions as an additional information. Then, they send the information to the nearby station and there it is recorded with the locaion of the ships. The ground weather stations send balloonst containing weather instruments in the morning and evening to measure upper air conditions and wind movements. Finally information from all stations will be collected in a regional centre and there it is processed and weather forecasting is done.

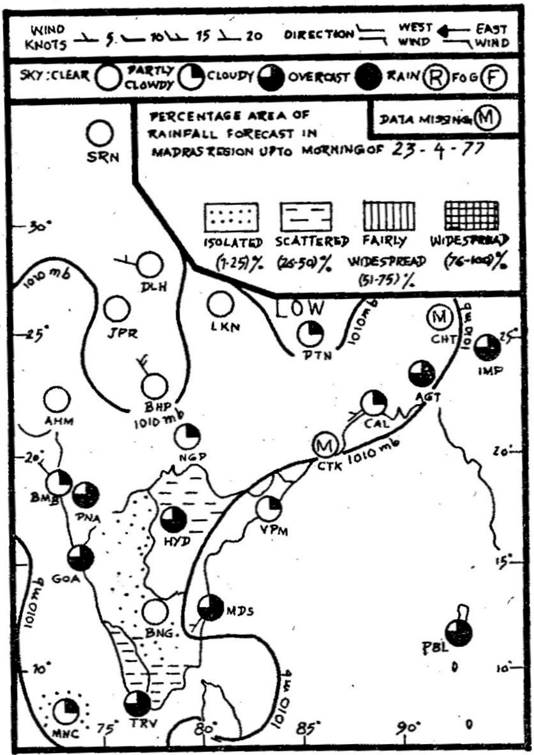

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Fig. 14.6

Weather Map

Weather Satellites

On April 1, 1960 United States of America successfully sent a rocket carrying a weather satellite to the space. This satellite is a weather observational station encircling the world. Weather satellties are able to provide cloud types and associated weather conditions. Such information provides clear picture of the surface and upper air conditions. Satellites are invaluable information store houses as they detect the development of tropical cyclones. Modern electronic scanners

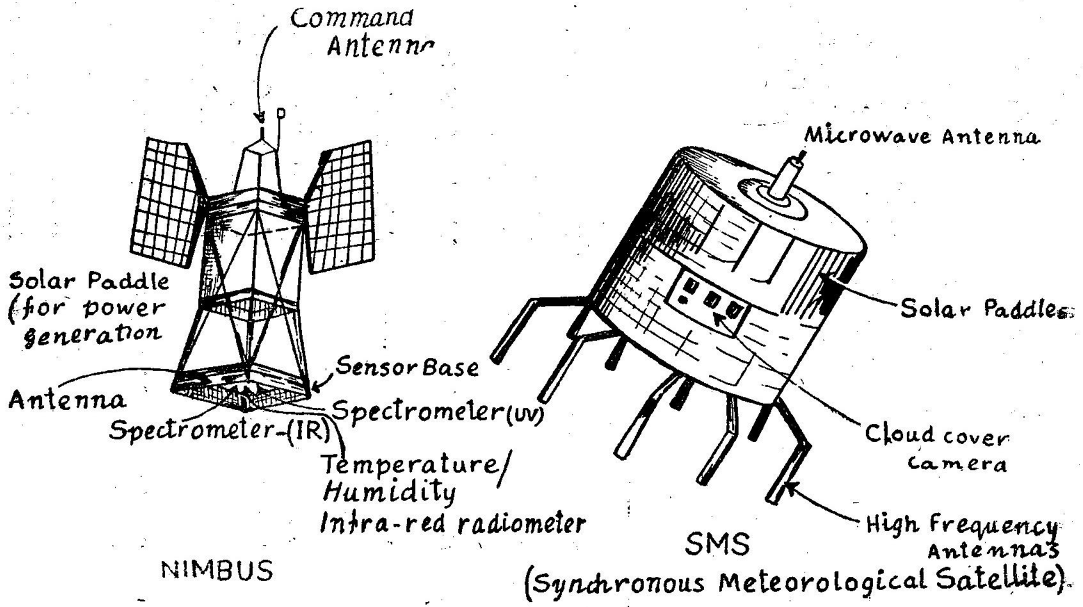

Fig. 14.7

Examples of Weather Satellites

and more sophisticated special purpose cameras are fitted in the satellites. These instruments are capable of giving detailed information on various weather elements. Apart from cloud types they gather information about the thermal structure of the atmosphere also.

These satellites are unmanned and are controlled by scientists from the ground. Satellites travel in near circular routes and will be above the altitude of 150 kms. and above. Their sizes vary greatly. Two examples of satellite models are given. Some details on different meteorological satellites are given below :

		Name	Purpose
TIROS	—	Television and Infra-red Observation Satellite	Especially to test different instruments,
NIBBUS	—	(Means Cloud)	Weather Satellite
ESSA	—	Environment Survey Satellite	Advancement of TIROS
ATS	—	Application Technology Satellite	All possible information on Ground Resources and Weather Information
SMS	—	Synchronous Meteorological Satellite	Weather Satellite
NOAR	—	National Oceanographic and Atmospheric Administration Satellite	Oceanographic and Atmospheric Surveys

Therefore satellites are able to provide very valuable nformation in different forms and for different purposes.

Weather Analysis and Forecasting

Since weather is the most important component of the environment which to some extent shapes the life of the people in the monsoon countries, the collection of weather information has more practical uses. Based on the information collected weather conditions of the different locations are analysed. This enables, to make a generalization of weather conditions of a region or a country. By the analysis they establish the nature of different weather elements and their influence to each other. This helps us to know in certain extent that what is going to happen next. This is called weather prediction and forecasting. For example, landing of aeroplanes and sailing of ships are associated with what is going to happen to the atmosphere and sea. So what is called a short-term analysis of the weather conditions will be made. In case of agricultural planning a long-term analysis of the weather conditions will be done.

EXERCISE — 14

Short answer questions

1. How it information gathering useful for the understanding of the environment ?
2. What is the need for sample survey methods ?
3. What are the details recorded by ground survey methods?
4. What are secondary informations ?

5. How remote sensing is important to survey the environment ?

6. Write a short note on 'Satellites' and 'Weather information.'

Essay questions

1. Describe the different types of information.

2. Write an essay on aerial survey methods of information collection.

3. What is weather information ? Describe the role of meteorological stations on weather information gathering.